Shipboard Curriculum Guide
Lake Erie Science

A Guide for Preparing, Producing and Extending an Understanding of Great Lakes Science through Experiential Learning for Middle through High School Students

Experiencing, Investigating, Learning

Sea Grant Pennsylvania

LAKE ERIE SCIENCE FIELD STUDIES
GANNON UNIVERSITY

WINNER
2001 GOVERNOR'S AWARD FOR ENVIRONMENTAL EXCELLENCE

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Experiential Learning = Learning by Experience

"Tell me and I will forget,
Show me and I may remember,
Involve me and I will understand…" **(Confucius)**

INTRODUCTION

Pennsylvania Sea Grant, the National Oceanic and Aeronautical Administration (NOAA), Gannon University, the Regional Science Consortium at the Tom Ridge Environmental Center and the Erie Maritime Museum have teamed up to provide the opportunity for students to participate in a unique, hands on educational experience.

Students have the opportunity to board the Research Vessel (RV) ***Environaut*** a 53 foot historic fishing boat converted to a research vessel and the ***US Brig Niagara***, a 200 foot traditionally rigged vessel, and Pennsylvania's Flagship, to engage in significant scientific research while learning about the environmental health and ecology of Presque Isle Bay. Students will be transformed into sailors and lake biologists for a day as they raise the sails, operate scientific sampling equipment and search for aquatic life.

Through funds provided by the National Sea Grant office, shipboard learning experiences have been made affordable for local schools. The Pennsylvania Sea Grant Shipboard Education program is composed of two distinct programs. The " Lake Erie Science" program aboard the *Environaut*, and the "Tall Ship" program aboard the *Niagara*. Both these home ported ships provide a unique field experience for teachers and students.

Although the learning stations are similar on ships and programs, this curriculum will focus on the activities on the RV *Environaut* which is a designated by the United States Coast Guard as a Research Vessel and is equipped to conduct scientific research.

The intent of this curriculum is to provide a framework for participating schools and resources to extend the learning process into the classroom. Participants will gain a deeper understanding of environmental issues that affect Presque Isle Bay and Lake Erie environments as well as become active participants in caring for and protecting their environment.

Goals

The goals of the Shipboard Education Program are to:

- Foster an awareness of environmental issues and concerns affecting the Lake Erie region.
- Create environmental stewards of our fragile environment of Presque Isle Bay.
- Provide students with a unique maritime experience aboard local ships and provide access to Presque Isle Bay and Lake Erie.
- Prepare students by pre-field experience lessons, document the learning station procedures, and extending the analysis into the classroom.
- Build a collaborative of academic, science and maritime agencies to support and promote Lake Science.

Curriculum

This curriculum is designed to prepare students for their field experience aboard the ***Environaut*** or ***US Brig Niagara***. The lessons are designed for 7-12 grades, but can be adapted for most grade levels, with all lessons touching on some aspects of the Pennsylvania Academic Standards.

Extension lessons are included in the back of the curriculum that touch on current issues facing the Great Lakes. Laboratory procedures in the classroom are intended to extend the analysis and understanding of environmental quality by utilizing sediment and water samples obtained during the field experience.

Not all materials included have to be reviewed in their entirety, but it is ***strongly*** recommended that the activities and procedures for the field experience be reviewed with the students prior to the field trip.

Cross-Curricular Applications

Most of the lessons have a predominately science theme, but incorporate some aspects of other traditional academic subjects such as language arts, mathematics and social studies.

Some of the skills students will use in each area include:

Science process skills: Students will learn about Observation, measurement, classification, inference, prediction, communication, formulation of hypotheses, experimentation, and data interpretation.

Language Arts: Students will talk and write about the exciting science activities they are doing, as well as their personal interpretation of their experiences.

Mathematics: Many of the scientific investigations and observations will result in an opportunity for students to apply mathematical skills such as algebra in a variety of ways..

Social Studies: Students will learn about past human activities and about their influences on the present and future.

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For more information about these programs, consult the ***Pennsylvania Sea Grant*** website at http://www.seagrant.psu.edu or contact staff at the addresses listed below.

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Regional Science Consortium
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PRE-FIELD EXPERIENCE

PRE-FIELD LESSON PLAN

GRADE LEVEL/SUBJECT
Grade 7-12: History/Physical Science

TIME
1-2 class periods

PURPOSE The purpose of this lesson is to introduce students to the importance of the Great Lakes, Lake Erie and Presque Isle Bay. The other important aspect of this lesson is to help students realize the importance of field work to gather data on the aquatic environment on an on-going basis to monitor the ecological health of the Great Lakes. Students will also be exposed to an overview of the role of ships by looking at the history and nomenclature of a research vessel and the tasks performed by scientists which become the learning stations during the field experience. This lesson also presents an opportunity for students to judge the merits of a career as an aquatic biologist.

OVERVIEW The Great Lakes is a unique resource on our planet, yet very few people understand the complete role the Lakes play in our survival. A "What you Know- What you want to Know - What you have Learned (KWL) assessment is provided as it serves as a pre-assessment of student knowledge regarding the Great lakes as well as a reflection of the field experience which is a hallmark of experiential learning. The focus of this overview will be the Research Vessel (RV) *Environaut* and the standard procedures employed to conduct research in the field. An overview of the learning stations and a ship diagram will be provided to familiarize students with ship operations.. This lesson will provide students with the knowledge and confidence to participate as members of the crew and create a memorable learning experience.

OBJECTIVES
At the end of this lesson students will:

- ✓ Understand the importance of the Great Lakes, Lake Erie and Presque Isle Bay.
- ✓ Become familiar with general nomenclature associated with boats, and the RV *Environaut* in particular.
- ✓ Understand the purpose and locations of the learning stations and what type of research equipment is deployed to obtain environmental samples.
- ✓ Demonstrate their knowledge of the general responsibilities of a research assistance/crew member and safety requirements.

RESOURCES/MATERIALS

K-W-L Activity Sheet
Great Lakes Fact Sheet Assessment
"Test Your Great Lakeness" Power Point Presentation
Boat Diagram

MOTIVATION

- Assess your students' knowledge of the Great lakes with the power point presentation "Test Your Great Lakeness"
- Have students complete the Great Lakes Trivia Quiz/Assessment
- Pass out the K-W-L worksheet and have students complete the "K" section prior to the introduction and the "W" section after the introduction.

ASSESSMENT

- ✓ Have students complete the diagram of the Environaut and label stations and general features of the ship.

TEACHER RESOURCE INFORMATION

The Great Lakes

The Great Lakes are the largest group of freshwater lakes on the earth by total surface totaling 94,250 square miles. These combined lakes consisting of Lakes Superior, Huron, Michigan, Erie and Ontario contain 21% of the worlds surface freshwater. These lakes, sometimes referred to as the North Coast, form a chain connecting the interior of North America to the Atlantic Ocean. With the exception of lake Michigan, the lakes form a water boundary between Canada and the United States. Access to the Atlantic is by way of the St. Lawrence Seaway and a series of canals connecting the Great Lakes. Access to the Gulf of Mexico is via the Mississippi River through the Sanitary Ship Canal in Chicago.

The Great Lakes were formed approximately 10,000 years ago at the end of the last glacial period. The retreat of the Laurentide Ice sheet left behind a large amount of melt water which filled up the basins that the glaciers had carved.

Before the arrival of the Europeans, the Great lakes provided fish to the indigenous groups who lived on the shores. Fish populations were the early indicators of the condition of the Lakes, and have remained one of the key indicators of ecological health to this day. Overharvesting by European settlers was cited as responsible for the decline in commercial aquatic species. Between 1879 and 1899 whitefish harvests declined from some 24.3 million tons to 9 million pounds. The use of gill nets and weirs at the mouths of tributaries decimated fish populations and as early as 1860 the Canadian government declared a complete absence of the once plentiful salmon runs. The giant freshwater clam was eliminated as the mussels were harvested for production of buttons by early Great Lakes entrepreneurs.

Other factors introducing by man further compromised the natural ecosystem of the Great Lakes during this period. Extensive logging compromised spawning beds and introduced sediments into the water. Water obstructions such as dams and canals disrupted the migration and spawning patterns of fish populations.

Today, major contributors to ecological problems have stemmed from urban runoff, sewage disposal, toxic industrial effluent and the introduction of aquatic invasive species.

Presque Isle Bay

Presque Isle Bay is a natural bay sheltered by what geologists call a “recurved sand spit”. This peninsula, which is now Presque Isle State Park, was formed on a moraine during the end of the Wisconsin Glaciation period and is constantly being reshaped by winds and waves., There are seven ecological zones within the 3,112 acre park as well as 21 miles of trails and 13 swimming beaches. The Bay and Peninsula served as the homeport of Commodore Oliver Hazard Perry's fleet during the war of 1812. Presque isle State Park receives over 4 million visitors per year, second only to Yellowstone Park.

The Bay itself is a unique sheltered habitat for aquatic life. It has been the focus of extensive research and study. A more extensive lesson in the history of Presque Isle Bay and its transition from an Area of Concern (AOC) to an Area of Recovery (AOR) is located in the Resources section of this document.

Research Vessel (RV) Environaut

a. Ship History

The Research Vessel (R/V) Environaut was built in 1950 in Erie, PA by the Pasche brothers. She was one of the last boats built as a commercial fishing vessel when Erie was considered the "freshwater fishing capitol of the world". From the 1880's until the mid 1950's the blue pike was fished heavily and became the most successful economic industry of Erie. At one time there were approx 120 registered commercial fishing vessels along the waterfront in Erie. The shore and dock areas were lined with ice houses, processing warehouses and rail lines packaging and transporting the blue pike all over the world. By the mid 1950's the blue pike had become extinct from overfishing and the city of Erie began the transition from a fishing port to an industrial port.

During this time the ship was known as the "Little Toot". After the failure of the fishing industry the original 36 ft vessel was retrofitted for a new career. During the winter the ship had a 17 foot section added at her amidships to extend her length and capacity to 48 feet. In addition a paddle wheel, seating and smoke stacks were added to the superstructure to resemble a steamship. For the next 20 odd years she served as a harbor tour boat and ferry between Erie and Presque isle State Park. Owned by the Rugare family, she was a regular fixture on the docks near Dobbins landing. Throughout the 1970's the Little Toot struggled to earn it's keep as a tour boat and was transported to Pompano Beach Florida in the 1980's where it became a tour boat on the Intracoastal Waterway for several years. As the competition increased upon the docks with newer and larger boats the Little Toot was sold to Gannon University in the 1990's and underwent its next retrofit as a research vessel.

Renamed the Environaut, the ship was designated as a Research Vessel by the US Coast Guard to support the Science Department at Gannon University. For over 20 years the ship has supported Dr. Zagorski's Limnology class at the University, and provided opportunities for students to conduct research in the field aboard the ship.

The Environaut is the only designated Research Vessel maintained by an academic institution in the local area.

Environaut is certified to carry 20 passengers on field excursions for educational purposes and research activities on Lake Erie. She is 48 feet long, weighs 15 tons, and is powered by 471 Detroit Diesel. It is helpful to have knowledge of the nomenclature of the boat before attempting to board for the field experience. Some basic terms that are essential to boat orientation are **bow, stern, port,** and **starboard.**

Safety is a primary focus on the ship at all times. All students are required to wear personal Flotation Devices (PFD) and follow directions given by the Captain and crew. Students are expected to dress for the weather, no–open toed shoes

b. Learning Stations aboard the Environaut

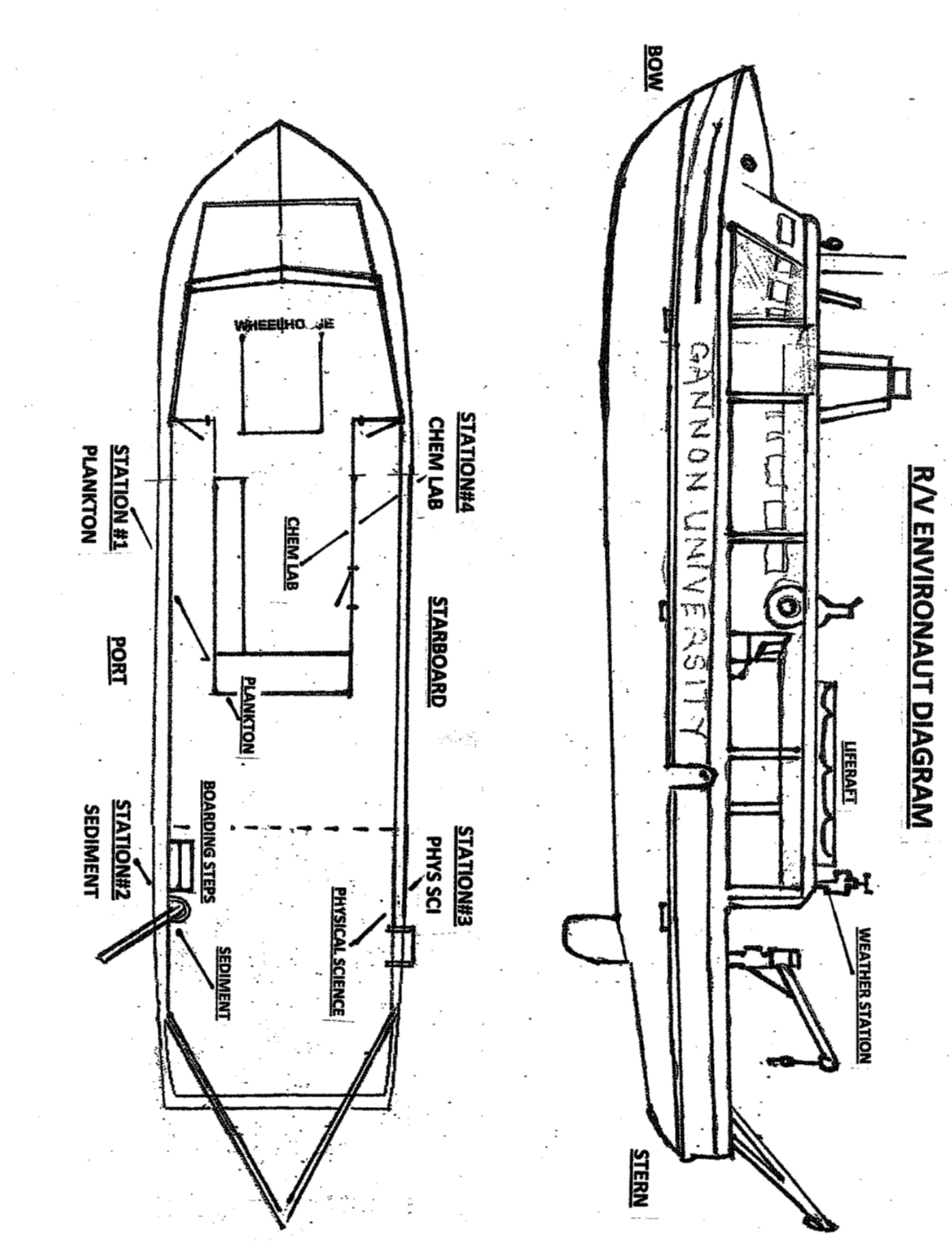
Listed below are the learning stations facilitated aboard the ship during the field experience. The locations are noted on the boat diagram for student familiarization, and further explanations are provided in the field experience section of this curriculum.

Station 1- Plankton Sampling

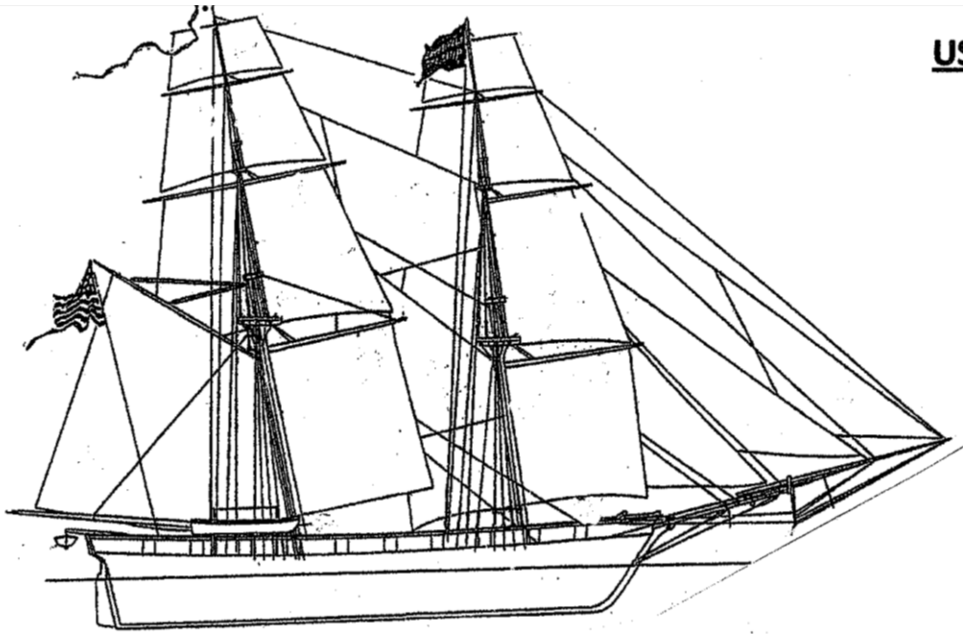
Station 2- Sediment Sampling

Station 3- Physical Sampling

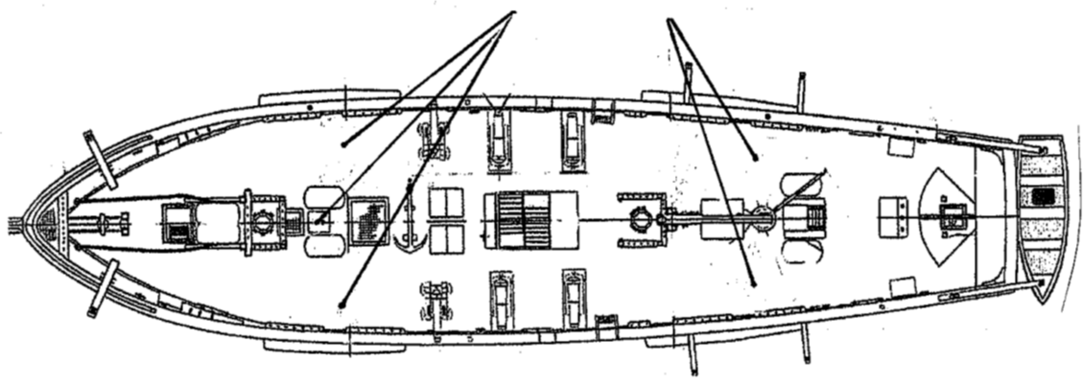
Station 4-Chemical Sampling


R/V ENVIRONAUT DIAGRAM
BOW
STERN
GANNON UNIVERSITY
LIFERAFT
WEATHER STATION
STATION#4
CHEM LAB
CHEM LAB
STARBOARD
STATION#3
PHYS SCI
PHYSICAL SCIENCE
PLANKTON
BOARDING STEPS
SEDIMENT
STATION #1
PLANKTON
PORT
STATION#2
SEDIMENT

US BRIG NIAGARA DIAGRAM



Sparred Length	198 feet
Hull length	123 feet
Beam	32 feet
Draft at sternpost	10 feet, 8 inches
Displacement	297 tons
Tons burthen (old measure)	492 60/95 tons
Mast Heights (above water line)	
Foremast	113 feet, 4 inches
Mainmast	118 feet, 4 inches
Armament	18 /32 pound carronades
	2 /12 pound carronades
Crew (1813)	155 officers and men
Crew (1993)	16 professional
	24 volunteers



FIELD EXPERIENCE

ORIENTATION

Boarding passes, waiver forms and confirmation sheets are provided to teachers prior to the field experience date outlining the activities of the excursion. Students meet at the entrance of the Erie Maritime Museum and walk to the charter boat docks to be introduced to the Captain and the instructors. All required paperwork including liability waivers and payments are to be made before boarding the boat.

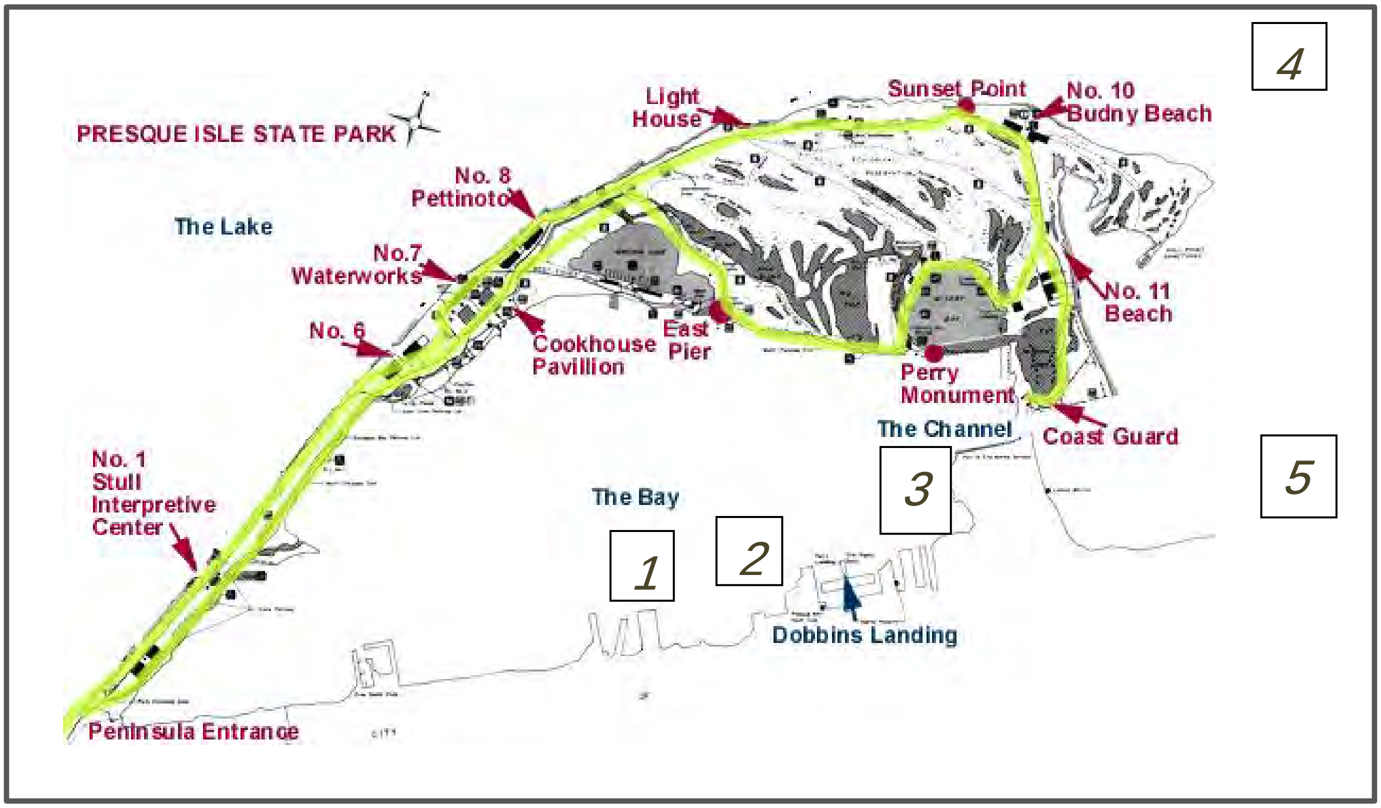
Students board the boat and receive a safety orientation from the Captain prior to departing from the dock. As the boat departs the dock enroute to the sampling site, students will be assessed of their knowledge of the Great Lakes and receive an overview of the scientific tasks facilitated at the learning stations. During this time the students will be divided into four groups to prepare for assignment to various stations. Students will be deployed to stations after the Captain has set the anchor and the instructors have completed the whole group surface tow collection.

Students will rotate to each station upon completion of the activity until all students have participated in each activity.

(NOTE: Weather conditions will determine location of sampling sites and course of the field excursion as determined by the Captain. Excursions on the US Brig Niagara do not include sampling ; all samples are obtained previous to sailing).

The field methods for each learning station have been categorized into physical, chemical and biological parameters. These parameters will provide an opportunity for students to become familiar with the scientific methods used in the study of lake processes or Limnology. All of the methods and equipment used are standard field sampling procedures and are suitable for scientific discovery and reporting.

SITE SAMPLING



Sampling Locations:

1. Cascade Creek
2. Dobbins Landing
3. Mill Creek
4. Open Water
5. Hammermill Cribs

PLANKTON

Surface Plankton Sampling– Whole Group Activity

A tow net sample is collected as the boat slows to a speed of 1mph. Plankton net with a mesh size of 10 microns attached to a nylon rope is towed along the surface of the water for 2-3 minutes. This is a whole group activity using assigned students from the group. After the sample is collected, the plankton net is hung to concentrate the sample and is used as the shipboard plankton identification process using microscopes. If classes are planning to extend the identification process to the classroom, the sample can be mixed with a 10% formalin mixture and put on ice and to be transferred to the school.

Learning Station #1 – Vertical Plankton Sampling

Samples are taken from the top, middle and bottom of the water column at the sampling site using a 4.2 liter Kemmerer sampling tube. Samples are drained into a 10 micron nanoplankton net attached to a 42-ml vial. Samples are allowed to drain and concentrate prior to being analyzed. Students will collect the samples upon direction from the instructors. After the samples have been concentrated, slides will be prepared to view organisms under the microscopes. Students will use the provided field guides to identify specific plankton and record the results on a data sheet.

(NOTE: Based upon the location of the sampling site, the collection of water column samples may be limited to surface samples based upon the water depth at the site).

LEARNING STATION #2 – Benthos Sampling Procedures:

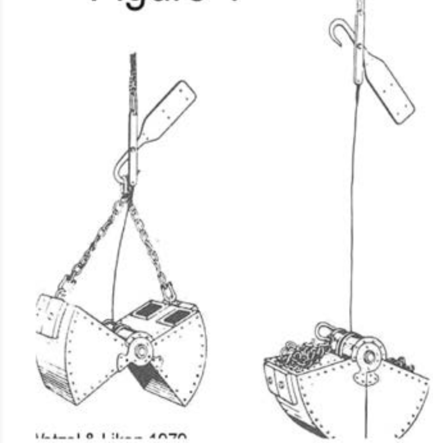
INTRODUCTION

The following procedure is a step-by-step description of the sampling process that will be carried out while on board the Research Vessel Environaut. Three samples of the benthos will be collected from a specified site on Presque Isle Bay or Lake Erie. The benthos are the organisms that inhabit the bottom substrate of lakes, ponds, and streams. Many benthic insect larval forms are a major food source for small fishes. Before you begin, there are a few things you will need to know. Please read.

THE PONAR DREDGE

We will be using a Ponar dredge that is mounted to the hoist. A Ponar dredge (Figure 1) allows the user to collect samples from the bottom (or benthic) layer of sediment in a body of water. The jaws of the dredge consist of a spring-loaded trigger mechanism that will automatically close when the dredge hits the bottom, thereby collecting the samples. The dredge is then pulled back to the surface and the contents emptied into a plastic container.

Figure 1



Safety Note: It should be noted that this dredge has a trigger mechanism that can catch loose clothing, fingers or any other body part if it happens to get in the way.

THE DREDGING TEAM

Once at the designated sampling site, students and instructor will be responsible for retrieving samples using the Ponar dredge.

1. Students will be assigned to controlling the dredge and emptying the samples into the container. Students may rotate positions throughout the process. An instructor must oversee this activity.
2. Preparing the dredge:
    a. Once the dredge is properly secured, begin to lower the dredge into the water.
3. Lowering the dredge:
    a. The dredge should be lowered slowly and consistently
    b. Once the dredge hits the bottom, the lines should be given some slack to allow the dredge to close.

    c. At this time, the students who are monitoring the line should begin to raise the dredge.

4. Raising the dredge:
    a. As the dredge is being raised, it is important that it is lifted slowly and consistently to prevent losing any of the sample.
    b. Once the dredge is at the surface it should IMMEDIATELY be positioned directed above the plastic container on the deck and the contents emptied.
    Note: To prevent losing some of the smaller organisms it is important that the dredge remain out of the water for as little time as possible.

5. Emptying the Samples
    a. Once the dredge is over the plastic container, the contents should be emptied directly into the container.
    b. Once the dredge is emptied, the dredge should be cleaned and returned to its original position.
6. Repeat steps 1-6. two more times.
7. After the samples have been taken, the sediment sieving process can begin. The dredge should be cleaned and stored properly.

LEARNING STATION #2 – Sieving Procedures

INTRODUCTION

The following procedure is a step-by-step description of the sieving and sorting process to be completed following collection of samples aboard the Research Vessel *Environaut*. Students will have the opportunity to search through their samples, sort and identify organisms that may be hiding in the mud and gravel. They will also have the opportunity to use the microscope to further analyze and identify the organisms they found using the field identification guide. Students will record their collection results on the data sheet provided.

THE SIEVE

A sieve is an apparatus used to separate sediment and water from organic debris such as rocks, plants and organisms. Figure 1 depicts a sieve screen containing organic debris. Round metal sieves with three different screen (or mesh) sizes will be used. Sizes range from a no.5 mesh size used to separate larger organisms to a no. 230 mesh, a finer mesh used to separate the smallest organisms.

Figure 1: The Sieve Box

THE SIEVING PROCESS

NOTE: Students will be split into groups with one instructor at each learning station. For the sieving activity students should have 3 round sieves, sediment containers, ice cube trays, a hose, a scoop and a few pairs of forceps.

1. Students will be assigned tasks: hose, scooper, multiple searchers.
2. A small portion of the sediment sample in the blue tub should be scooped into the sieve.
3. The sieve should be gently sprayed down to rinse the mud away and separate any gravel or debris from the organisms.
    a. When spraying the sieve spray lightly and go in a circular motion
4. Carefully examine the contents on the first screen. *(You may notice that most of your sample falls through to the next screen)*
5. Using forceps *carefully* remove any organisms and place them in the ice cube tray. *It is important that you look VERY closely at the screens* Once all organisms are removed from the first sieve screen, remove it and go on to the next screen. When you remove the first screen you will need to look harder and harder to find organisms.
6. After removing all organisms from the last sieve screen, flip the sieves upside down on the bucket and rinse the sieves and repeat steps 1-6 until all samples are sorted!
    a. CLEAN UP! All equipment should be washed and properly stored.

LEARNING STATION #3 - HYDROLAB® / YSI SAMPLING PROCEDURES

INTRODUCTION

Students will use a "Hydrolab" or "YSI" unit to assess water quality parameters aboard the Research Vessel Environaut. They will learn how to operate the equipment, as well as learn about how each parameter relates to the health of the water in Lake Erie and Presque Isle Bay. The standard parameters being recorded are: temperature, pH, dissolved oxygen and conductivity. Students will assist in taking the readings and recording the data.

THE HYDROLAB ® UNIT

The Hydrolab/YSI is an electronic instrument that is used in monitoring water quality. It consists of a digital display with an attached cord and probe (Figure 1). When the probe (Figure 2) is placed in the water it can measure several different water quality parameters depending on the model. The parameters we will be concerned with are dissolved oxygen (D.O.), pH, temperature and conductivity. Each parameter's value is recorded on the digital display unit. The operation of the unit is straightforward. Once the unit is calibrated the user places the probe in the water and allows a few seconds for the reading on the digital display to stop fluctuating. The readings are recorded and the process repeated.

Figure 1: The Hydrolab Unit

WATER QUALITY PARAMETERS

A Closer Look: The probe

Each parameter (temperature, dissolved oxygen, conductivity and pH) we will be sampling for tells us something important about the health of Lake Erie and Presque Isle Bay. Each of these factors are limiting, that is, each has a maximum and minimum value, above or below which life for many species cannot continue.

Temperature directly affects the rate of biological activities. Every organism has an upper and lower tolerance limit for temperature and a certain temperature range that they prefer. Most organisms will try and remain near the center of their range. Water forms temperature layers at different depths through a process called thermal stratification, however Presque Isle Bay does not stratify and the temperature is relatively uniform throughout; Lake Erie does stratify. The upper, warmer layer is the ***epilimnion;*** the layer of transition from warmer to colder waters is the ***thermocline*** (represented by a drop in temperature of 1°C for every increase in depth of 1 meter); and the lower, colder layer is the ***hypolimnion***, which has a relatively uniform temperature. A rapid increase or decrease in temperature can have a negative impact on aquatic life.

Dissolved oxygen: Oxygen is one of the most important environmental factors in aquatic systems. The atmosphere contains approximately 20 percent oxygen in the gaseous state but is typically found in lower amounts in aquatic environments. The oxygen found in the water is dissolved in solution and therefore is less available to the organisms. The relative amount of dissolved oxygen in aquatic environments is measured in parts per million (ppm). The amount of dissolved oxygen in the water can potentially become a limiting factor for many organisms. For example, most fishes need dissolved oxygen levels of 6 ppm to survive, however, some species like carp and catfish can survive in as low as 4 ppm.

Conductivity is directly related to the amount of chemical ions in the water. Dissolved solids present in the water exist as ions and their solution can conduct an electrical current. A high conductivity reading implies that there are a lot of ions present in the water and is associated with fertile lakes; a lower conductivity implies fewer ions present and is associated with relatively infertile lakes. Metals such as aluminum, copper, magnesium and mercury exist as ions in the water. The higher the conductivity reading, the higher the concentration of heavy metals in the water. The conductivity does not say which metals are present, simply that there are metal ions in the water.

pH expresses the concentration of hydrogen ions in an solution on a scale that runs from 0 to 14. On this scale 7 is neutral; below 7 is acidic; and above 7 is basic. The scale is exponential; i.e., the concentration of hydrogen ions at pH 6 is actually 10 times that of pH 7. An example of a basic solution would be Alka-Seltzer dissolved in water it would have a pH greater than 7.0 since it is composed of sodium bicarbonate. It is used to neutralize the acid in your stomach which would have a low pH below 7.0. Aquatic organisms can be very sensitive to pH fluctuations. Most aquatic organisms prefer a pH of around 7. Some fish species can tolerate a pH levels as low as 5.0 however most would prefer ranges of 6.5 to 9.0. Mayfly nymphs are very sensitive to pH, if the pH were to drop as low as 5.0 it could virtually wipe out their entire population.

b. Secchi Disc

Transparency is measured by Secchi Disc observations. The smaller disc is an eight inch circle with alternating black and white quarters. The larger disc is uniformly white and twenty inches in diameter. Both discs have black length marks on the nylon cord measuring meters. The disc is lowered into the water until it disappears and then raised until it reappears. Students will count the number of meter marks to determine the depth of the Secchi to determine transparency. The average of these two depths (in meters) is recorded as the limit of transparency.

c. Sounder (Water depth)

Readings at all sampling sites will be taken with a lead-weighted calibrated nylon corded bell disc. The "sounder" will be lowered into the water and lowered until it reaches the bottom which results in a slack line. Students will count the meter marks on the nylon cord and record the depth on the provided data sheet. It is appropriate for a student to verify the sounder depth by checking with the Captain to verify the readings at the helm and compare those figures with the depth determined by the sounder.

d. Weather Station

The Environaut is equipped with a "Watchdog" weather station located aloft on the canopy of the boat that displays current weather conditions. Students will record weather conditions on the provided data sheet and make a visual observation to verify that data. Typical data collected is wind speed, temperature, wave height, cloud cover and rainfall.

LEARNING STATION #4 – Chemistry Lab

Water samples for chemical analysis are taken using a 3 L Kemmerer sampler. The Kemmerer is a large, acrylic sampling tube attached to a nylon rope which is lowered to the desired depth. A brass messenger is then sent down the rope, triggering the sampler to close. Samples may be obtained at different levels in the water column depending upon the depth at the sampling site. Data is collected and recorded at different depths and compared to analyze variations. Generally commercial Hach or LaMotte Water test kits are used to collect data.

All testing is conducted at the on-board lab on the Environaut. Most of the parameters tested require a reagent to be added to the sample, and require a period of time for the results to be determined. All data is recorded on a data sheet provided. Some of the standard testing procedures used to analyze water quality levels require laboratory equipment and 24-48 hour incubation periods. For this reason, only testing that can be completed within the period of the field activity are conducted.

An example of a standard extended test for water quality is Coliform bacteria which requires a temperature controlled 24 hour incubation period to indicate whether coliform is present. In order to determine the level of contamination, a colony count using laboratory equipment must be conducted. Coliform bacteria normally live in the intestines of mammals and are excreted with the fecal wastes. Some forms are pathogenic, but even if they are not, if they are present in a water sample this indicates that the sample has been through an animal intestine. The Environmental Protection Agency standards do not allow any level of coliform to be present in drinking water.

The following is a list of common parameters tested in the Chemistry lab during the field excursion:

pH Test – pH measures how acidic or basic a substance is. The pH scale ranges from 0-14. A ph of 7 is neutral. A pH level above seven is considered basic and below 7 is considered acidic. Pure water is neutral, or 7. The presence of levels above or below the neutral level indicate the presence of contaminants. The figures below indicate ranges for aquatic life:

6.7 – 8.6	Well balanced fish population
5 – 9	Few fish can tolerate levels above or below
8.7	Upper limit for good fishing waters
7.5 – 8.4	Best Range for growth of algae

<u>Dissolved Oxygen (DO) Test</u> – Dissolved Oxygen is one of the best indicators of general water quality. As a general rule, the higher the DO level, the better the water quality. Dissolved oxygen is dependent on temperature as warm liquids hold less dissolved gasses than cold liquids. When organic wastes decompose in a body of water, dissolved oxygen is used up. Because more aquatic organisms are "cold blooded", their metabolism rises as temperature goes up and the amount of available oxygen goes down. This often results in fish "kills", especially if the DO drops below 5 ppm. The range for DO is between 0-15 ppm. The figures below indicate DO ranges and temperatures levels for aquatic life:

5 ppm and above	Growth and well being lower limit
6 ppm and above	Spawning, stonefly, mayfly limits
68 degrees F and below	Cold water organisms
68 degrees F and above	Warm water organisms

<u>Nitrates/nitrites Test</u> – Nitrogen compounds are essential for healthy plant growth. Nitrogen is a major constituent of commercial fertilizer. The presence of excessive amounts of nitrogen compounds in water supplies presents a major health hazard. Nitrates in conjunction with phosphates can cause algae blooms. The Environmental Protection Agency states that levels below 10 ppm are desirable. The figures below indicate ranges for aquatic organisms:

Nitrates - Trace amounts in most natural waters, less than 1 ppm
Acceptable levels for drinking water is 10 ppm or less

Nitrites - Levels as low as .3 ppm can be harmful to fish
Salmon affected as low as .06 ppm

<u>Phosphates Test</u> – Phosphates in water stimulates the growth of algae. This in turn can lead to accelerated eutrophication of a body of water. The concentration of phosphates in water is normally not more than 0.1 ppm, unless the water has been polluted. The following figures indicate the ranges for aquatic organisms.

6-10 ppm	Necessary for plant and animal life
.1 ppm	Healthy for rivers and streams
.01-.03 ppm	Acceptable levels for uncontaminated lakes
.015 ppm	Can cause algae blooms

POST FIELD EXPERIENCE

As an extension to the shipboard sampling experience, teachers may request sterilized samples of the water and sediments obtained onboard for extended analysis in the classroom. The following lessons are intended to add a classroom analysis component to further an understanding of the ecology of Lake Erie and Presque Isle Bay. Samples obtained in the field sampling phase of the field experience are sterilized with a 10% formalin mixture to prevent the spread of Aquatic Invasive Species.

The following lessons summarize accepted protocol for the identification and counting of micro and macro-invertebrates from the water and sediment samples. An advanced extension, involving the culture and plating of bacterial cultures can be arranged by request at the Regional Science Consortium Labs at the Tom Ridge Environmental Center. This unique opportunity exposes students to the spectrophotometer and associated equipment to process samples and work with scientists in a state of the art laboratory environment. This program is separate from the shipboard experience, and can only accommodate a smaller more advanced group of students and involves separate lab fees.

WATER LESSON: PLANKTON ANALYSIS

GRADE LEVEL/SUBJECT

Grade 9-12; Biological Science/Ecology

TIME

Two class periods

OVERVIEW

This lab activity involves the identification and counting of zooplankton and phytoplankton. Usually this activity is conducted at a microscope station with two student partners. As "Bio-indicators" specific types of plankton represent an accepted indication of water quality within the scientific community. Some types of plankton can only survive in a narrow range of chemical and physical parameters that are generally described as pollution sensitive, pollution neutral, and pollution tolerant. Generally, unpolluted waters support a greater diversity of aquatic organisms and polluted waters support larger numbers of more resistant or tolerant organisms. By identifying plankton types students will be able to categorize species by water quality requirements. This task accompanied by a count of specimens existing within a sample can provide an acceptable indicator of water quality.

BACKGROUND

Plankton by definition are organisms that are unable to swim against water currents. They are very numerous and form an extremely important part of the aquatic food web. Phytoplankton are producers, transforming sunlight into food energy. Zooplankton is food for many secondary consumers. The species composition of plankton provides an indicator for specific biological events. The classic example is algal blooms associated with eutrophication known as "red tides". During red tides, some organisms disappear completely as water quality deteriorates as do the number and diversity of plankton species. The amount of phytoplankton in a body of water depends upon light availability, and the relative proportions of specific nutrients. The amount of zooplankton in a body of water depends upon the amount of phytoplankton and detritus available to feed upon. Generally, plankton are more abundant in shallow, nearshore environments.

RESOURCES/MATERIALS

Stereoscopic microscopes 16mm (10-40X)

*A projecting scope is helpful for whole class demonstrations

Plankton samples (preserved)

Gridded slides

Pipettes

Data Sheets

Sea Grant; "Identification of Freshwater Invertebrates Guide"

Water Quality Indicator - Pollution Index Sheet

HANDOUTS

a. Microscope Diagram worksheet
b. Phytoplankton/Zooplankton Water Quality Indicator Data Sheet
c. Lake Erie Science Field Data Sheet - Microinvertebrates

PROCEDURES

1. Take specified, labeled sample container and shake thoroughly
2. Immediately place 2-drops using a pipette onto the slide
3. Make a wet mount slide (glass side up if using gridded slide)
4. Place slide under microscope and focus on left top grid
5. Moving from left to right using the microscopes hand dials, identify and count specific numbers and types of plankton. Use the Plankton Identification Guide to identify specific types of Zooplankton and Phytoplankton.
6. Record the results on the data sheet. Note sample site, date and longitude/Latitude
7. Repeat the procedure using another sample
8. Total the number of species by type and quantity on the summary sheet
9. Calculate the average totals of specific species of all classroom stations
10. Compare and contrast to the phyto/zooplankton pollution indicators data sheet
11. Develop a percentage breakdown of organisms found representing clean vs polluted waters.
12. Write a conclusion on the water quality of your sample, provide data to support your findings. Share your results (Dispose of your water sample properly)

TIPS/VARIATIONS

a. If the organism is positioned on the border of a grid block, count only whole specimens
b. During examination, always begin with 5X to gain focus and move to 10X or 40X for identification
c. Colonies may be characterized as small medium or large depending upon the sample
d. Presence or absence of detritus should be noted to support justification of conclusion
e. The presence of of filamentus forms should be characterized by small, medium or large in length
f. If lab time is limited, students may draw plankton shapes, focusing on distinguishing characteristics and focus on identification of species.
g. If a non-planktonic species is discovered, have student characterize and conduct species specific research to determine function/presence in the water column. (Example: Zebra mussel veliger)
h. As time permits, an extended chemical analysis of parameters not tested aboard the ship, due to incubation requirements, can be conducted in the classroom.
i. Compare and contrast samples from different locations in the water column.

GLOSSARY

Anaerobic – Condition in which free oxygen is absent

Aphotic Zone – Deep layer of water where penetration of light is not sufficient to permit photosynthesis

Autotrophic/Producer - An organism that through photo or chemosynthesis produces its own nutrition.

Bio-indicators – Living organisms used to determine water quality.

Bacteria – Single celled organism important in the decay of organic material.

Consumer – An organism that gets its food from eating other organisms.

Detritus – Dead and decaying organic material

Decomposers – Organisms, usually fungus and bacteria that break down plant or animal materials.

Eutrophication – The process by which a body of water becomes rich in nutrients and biological productivity is stimulated

Heterotrophic – A secondary producer that survives upon the organic material produced by an autotrophic organism.

Eutrophic Zone - The upper layers of water where light penetrates and photosynthesis can take place, thus the growth of green plants and algae.

Indicator Species – A species whose occurrence serves as evidence that certain environmental conditions exist.

hytoplankton – Plant plankton. (primary producer)

Zooplankton – Animal plankton. (primary consumer)

REFERENCES

"Laboratory Manual for Limnology" Dr. Stan Zagorski, Gannon University, revised 2011

"Marine Science Consortium Pre-College Program, Fieldbook" Wallops Island Marine Science Center Academic Staff, 1995

"The Monitors Handbook," A Reference Guide for Natural Water Monitoring - LaMotte Co. Campbell/Wildberger 1992

"Field Manual for Water Quality Monitoring" Environmental Education Program for Schools, Mitchell/Stapp, Kendall/Hunt Publishing Company, 1996

"A Taxonomic Key to Common Phytoplankton in Lake Erie" Dr. Stan Zagorski, Gannon Univ.

"A Taxonomic Key to Common Zooplankton in Lake Erie" Dr. Stan Zagorski, Gannon Univ.

"Guide to Freshwater Invertebrates" Pennsylvania Sea Grant, Danielski/Grise', 2008

SEDIMENT-MACROINVERTEBRATE ANALYSIS

GRADE LEVEL/SUBJECT:
Grade 9-12
TIME:
2-3 Class periods

OVERVIEW:
This lesson will provide an outline of standard research methods to characterize water quality by determining species and quantity of macroinvertebrates (macros) present in a provided sample. As an extension to the shipboard sediment station, a further analysis of benthic sediments can provide insights in a lab setting that are not possible aboard the ship. By identifying and quantifying specific species, students will have evidence of water quality by the presence of "Bio-indicators present in the sample. It should be noted that this lesson is intended to familiarize students with research methods, and a generalized analysis. It does not provide an extended sampling base to definitively characterize a body of water over the seasons of the entire body of water.

Two additional variations are presented for benthic sediment analysis lessons which involve an alternative method of separating macros from the sample using a "Berlese sampler". The second is an analysis of the sediment particle size which is used by scientists to determine the extent in which toxins and heavy metals settle into the benthic environment.

BACKGROUND:
Aquatic macroinvertebrates (macros) are found in tributaries and streams that flow into the Great Lakes, as well as the Lakes themselves. By definition, macros are animals that have no backbone or spinal column that are visible without the use of a microscope. These macros help maintain the health of the water ecosystem by eating bacteria as well as dead and decaying plants and animals. Overall water quality effects which types of organisms can survive in a body of water. For example, mayflies require a narrow range of water quality and can be affected by chemical fluctuations in the water as well as toxins present in the benthic sediments. Aquatic worms and midges can survive in polluted waters and are very tolerant to swings in the chemical and physical changes in the environment.

The life cycle of a macro goes from egg to adult form and they can undergo either a complete or incomplete metamorphosis. Complete metamorphosis has four stages; egg, larvae, pupa and adult. Many of these organisms are aquatic for the egg and larval stages, but not in the adult stage. Other species can spend their entire life cycle in the aquatic environment. The length of the life cycle of macros can vary from less than two weeks to a full two years.

RESOURCES/MATERIALS:

Stereoscopic microscopes, 16mm (10-40X)
Sediment samples
Collector trays, Petri dishes
Hydrator bottles
Tweezers, scoop/plastic spoons
Data collection sheet
Laptop computer for internet access
Pollution sensitive species indicator list
Sea Grant; "Identification of Freshwater Invertebrates Guide"

HANDOUTS:

Data collection sheet
Web-based Macro field guides for identification; pollution tolerance

PROCEDURES:

1) Take provided sediment sample and "spoon" sediment on collector trays
2) Separate organisms from sediment and place in Petri dish for identification
3) Use microscope and field guide to identify species
4) Log species and quantity on data collection sheet;
   *Note date, Longitude and Latitude of sample site on data sheet
5) 5Characterize sediment sample as rock, sand or fine particulate on data sheet
6) Summarize data results by species and quantity
7) Write a conclusion to your water quality findings supported by your data/evidence
8) Share your results.
9) Dispose of your sediment sample properly

TIPS/VARIATIONS:

a) The microscope is used to make positive identification of macros; special attention must be given to verifying appendages and characteristics that distinguish specific species. Consider the differences in metamorphic stages of a species that can change the appearance of a macro.

b) Access to web-based resources for identification and pollution tolerances is important to verify species and tolerances; see resource section for links.

c) An important tool for distinguishing organisms is a taxonomic key that by the process of elimination provides researchers with a tool and a specific process to identify organisms.

d) A variation to determining water quality through the analysis of macros is to characterize the sediment particle size to determine disbursement rates of toxins and heavy metals introduced into the water through industrial processes.

c.1. Using three sizes of sieves, process sediment sample through sieves and determine the characterization of the sample as rock, sand, fine particles and detritus.

c.2. Develop a percentage for each characterization, i.e. 10% sand, 50% particulate, 40% detritus. This can be accomplished by weighing separated particle sizes, or by estimation.

c.3. Determine a risk factor for the likelihood of toxic containment, i.e. (0-10% for rock, 10-30% for sand, 30-60% for detritus and 60-100% for fine particules)

c.4. Write your conclusions regarding hazardous risk factors referencing the macro data conclusion and research studies which have examined other species exposed to benthic environments and resulting impairments, i.e. (Sea Grant Study of Brown Bullheads in Presque Isle Bay)

d) Another variation for biological sediment analysis is the construction and use of a "Berlese Sampler" to separate organisms from the sediment sample. The Berlese sampler is commonly used in terrestrial sampling efforts but can also be used with lake samples to extract organisms for identification. Sediment samples are placed in a can or funnel with a mesh screen at the bottom. A light is placed overhead to drive organisms towards the screen. Under the funnel or can is a mason jar filled with alcohol or formalin to preserve the specimens for identification.

After the organisms are isolated the same procedures are utilized for identification and counts of specific species. (See resource section for links to construction of Berlese Samplers)

VOCABULARY:

Benthic (Zone) – The ecological region at the lowest level of a body of water including the sediment surface and some sub-surface layers.

Berlese sampler – An apparatus that separates and preserves organisms from ground litter and sediment samples. Named after an Italian entomologist.

Formalin - A 37% water solution of formaldehyde used as a disinfectant and as a fixative for organism preservation.

Larva– A newly hatched wormlike form of many organisms before metamorphosis.

Macroinvertebrates – An organism without a backbone and visible to the naked eye.

Metamorphosis – The process of transformation from an immature form to an adult form.

Petri dish - A shallow circular dish used to culture bacteria or separate organisms, usually accompanied by a lid. Named after a German bacterialologist.

Sieves - An instrument with a meshed or perforated bottom, used for straining and/or sifting different sized particles/organisms.

Plankton net mesh size = 200-500pm
Typical Sediment sieve sizes = 1.0mm, 0.71mm, 0.42mm

Assessment Activities

OVERVIEW

Following your experiences aboard the Research Vessel Environaut, you may want to take the opportunity to provide some closure for your students and to discuss their experiences with them. Some of these activities can be done in the classroom or on the bus ride back to school.

ACTIVITY LIST

1. CREATIVE WRITING:
   - ✓ Encourage students to reflect on their experiences-what did they see? What did they hear? What did they do? What did they smell? Have each student write his or her thoughts on paper. Encourage them to be as creative as possible by writing a story, poem or drawing a picture.
   - ✓ Have students complete their K-W-L exercise with an extended emphasis on the reflective aspect of "what they learned". This will provide an opportunity to compare what they originally knew, what they wanted to learn, and finally what they did learn.
   - ✓ QUIZ: Test your student's memories of what they collected in the field.

2. COMPUTER APPLICATIONS:

   Through the Pennsylvania Sea Grant website students can view their data online and make inferences and predictions from their data.

   A. Data Analysis Questions
      1. Relative to their sampling position on the map of Presque Isle Bay, how could the surrounding environment affect their results? Example: Are there any streams emptying into the bay near your site that could contribute runoff or other pollutants? How would other streams in the Presque Isle Bay watershed affect your results?

      2. Looking at the number and types of invertebrates collected, use Microsoft Excel or other spreadsheet program to create graphs and charts displaying your findings. Did you find any mayfly nymphs? Why or why not?
         Note: *If students do not have access to a computer, have them draw their graphs and charts by hand using markers and construction paper*.

B. Microsoft Power Point Presentation

Your students may want to summarize their experiences and experimental results by creating a presentation they can share with other classes or their entire school. Pictures and data will be available online for downloading to use in the presentation. Creating a presentation is a great way to give your students a chance to be creative and also assess what the students learned through their Lake Erie Science experience.

TAKE HOME LESSON

It is our hope the ***Lake Erie Science*** experience aboard the Environaut:

- ✓ Exposed your students to their environment.
- ✓ Taught them about the components (both living and nonliving) of their environment.
- ✓ Gave your students an understanding of how they affect their environment.
- ✓ Helped your students become more aware of the issues affecting their environment and encouraged them to become stewards of their environment.

EXTENSIONS-GREAT LAKES LESSONS

Case Study: Mayfly

GRADE LEVEL/SUBJECT
Grade 7: Ecology/Environmental Studies/Biology

TIME One class period

PURPOSE The purpose of this lesson is to introduce students to mayflies and the environment, and to appreciate the relationship between the mayfly and the water quality of Lake Erie and Presque Isle Bay.

OVERVIEW Mayflies are insects that are considered water quality indicator species. Their presence in a lake or stream environment is an indication of good water quality conditions since they require clean sediments and an abundant supply of oxygen to survive. Water quality is something that affects everyone. We all use water everyday and assume that it is good quality and safe to drink. Pollution of the water can affect the organisms that live in Presque Isle Bay and in other environments. Presque Isle Bay located in Erie, PA was designated an **Area of Concern (AOC)**in 1991 because its sediments were contaminated. In 2002 Presque Isle received a change in designation to become the first Great Lakes Area of Recovery; however, there are still many improvements that need to be made. An improvement to the contaminated sediments could be indicated by the presence of mayflies.

OBJECTIVES
At the end of this section students will be able to:

- ✓ Identify a mayfly and know their basic biology and life cycle.
- ✓ Learn the relationship between the presence of mayflies and the overall health of Presque Isle Bay.
- ✓ Be able to see the effect that pollution can have on the ecology of Presque Isle Bay.

RESOURCES/ MATERIALS
Mayfly samples
Pennsylvania Sea Grant data sheets
Worksheet for each student

PRIOR KNOWLEDGE
Prior knowledge of the food web concept
Prior knowledge of insect anatomy/morphology
Prior knowledge of point and nonpoint source pollution

MOTIVATION

Ask the class:

- How many of you have ever been to the bayfront?
- How much do you know about water?
- Where does the water we drink come from?
- What do fish eat?
- When was the last time you ate fish? Do you know where it came from?

BACKGROUND INFORMATION

What is a Mayfly?

Mayflies are insects that can be found throughout the world. "Canadian Sailors" are the largest mayfly in North America and are common in the Great Lakes. You might know them as those pesky critters that cover the screens on your house or the hood of your car on a warm summer evening. In Erie, we usually see these insects emerge for the first time in the summer months beginning in June. Their body shape is very similar to other insects except for their remarkably huge wings! They have the three main parts of an insect: head, thorax and abdomen.

From Fremling & Schoening, 1971

Like many other winged insects, mayflies have different life stages. They live in the water as a **nymph** (Figure 1) stage for a very long time, but have a very short adult (Figure 2) stage. Therefore, most of their life is spent in the nymph stage on the bottom of lakes. They live in U-shaped burrows (at right) that they construct. Their food source is primarily microscopic particles that are present around their burrow. They can live in their burrow for up to two years, depending on the climate. The mayflies emerge when favorable conditions exist, the mayfly nymphs swim to the surface of the water and shed their **exoskeleton.** Once they have left their exoskeleton behind they are ready to spread their wings and fly! Amazingly, throughout the summer of 1999, so many mayflies were seen emerging from the water at night that they were captured on

E.C.M

Doppler radar by the weather staff at WJET-TV Channel 24. Weather conditions are believed to play an important role in the emergence of the mayflies.

As mayflies leave the water, they begin to search for a place to land. You can find them in abundance near bright lights. Mayflies are considered poor fliers. The adult mayfly (at left) may only live for three days! Neither the male nor female mayflies feed because their mouthparts are not fully developed. Since they only live as adults for a very short time, mayflies have to reproduce within a short span of time, therefore their main concern is finding a mate. Males swarm in one area and the females fly into that group in search of a mate. Once they mate, the female will fly out over a body of water, deposit her fertilized eggs directly onto the water's surface and die shortly thereafter. A single female can produce as many as 8,000 eggs! These eggs then sink to the bottom and after a few days or months a tiny nymph hatches from the egg. This completes the lifecycle of the mayfly.

Mayflies role in the food web

Mayflies play an important role in the **food web**. They acquire the energy from decomposed plant material and move it on to higher consumers (macroinvertebrates, fish, birds, etc.) Most importantly, they are a food source for many different kinds of fish, including walleye and yellow perch. It is thought that several endangered species of fish: namely sturgeon, whitefish, lake herring and silver chub consumed mayflies as a major portion of their diet. These species have been increasing in numbers possibly due to the return of mayflies, which is now readily available as a food source. More mayflies should result in more fish! The more fish, the more fish people have to catch and eat!

Why should we be concerned about mayflies?

Mayflies were very abundant in Lake Erie until the early 1950s when pollution from untreated sewage and industrial discharges contaminated the sediments. The nutrients in the untreated sewage produced tremendous growths of algae, which matured, died and decomposed.   Aerobic bacteria uses oxygen in the decomposition process of the algae. Consequently, when these large algal growths decomposed they used all the available oxygen in the lake bottom and the mayflies died out because they could not survive without oxygen.

Our technology and lifestyle play a big role in polluting our waters. In the 1960s and 70s we did our laundry with phosphate detergents and provided minimal treatment for sewage. In addition, human impacts come from development of surrounding land: landfills, sewage outfalls and industry. Since we depend on the water in Presque Isle Bay and Lake Erie for drinking, bathing, watering our lawns, washing our dishes, and many other things, it is important that the water is potable. In Erie, Presque Isle Bay (Figure 3) receives nonpoint source pollution in the form of runoff from streets and parking lots which can contain oils and other pollutants produced by cars and trucks. Fertilizer and pesticides are also added to the bay from lawns, gardens and other sources. The bay also receives Point source pollution from industrial and municipal discharge pipes.

These sources of pollution affect the animals living in the water. Certain animals are more sensitive to pollutants in the water. Mayflies are viewed as a **water quality indicator species.** In mayflies, the nymph stage is very sensitive to pollutants in the water and the sediments because they are in constant contact with the sediments where the pollutants can accumulate. If a pollutant impacts the water in high enough concentrations, the mayflies could die or their development could be affected. If the sediments are clean and the water quality is good then the mayfly nymphs will emerge normally. By monitoring the populations of these animals, we can get some indication of the water quality. If we don't see the mayflies emerging, as was the case in Lake Erie from the late 1950s until the early 1990s, we know that there is a problem. Could the increased quality of the water or sediments be the cause of their reappearance?

PROCEDURE

1. Begin a class discussion by asking questions: What kinds of insects do you see around your house in the summer? Then list these types of insects.

2. Display Figure 2. How many of the students recognize this insect? Are there other insects that they think look similar to the mayfly?

3. With that brief introduction now review: ***What is a mayfly?***

4. Pass around preserved samples of mayfly adults and nymphs so the students have a chance to view them.

5. Pass out a blank piece of paper to each student and have each student draw the preserved sample of the mayfly they have.

6. Display Figure 1 and discuss the mayfly life cycle. What noticeable differences do the students recognize between the two life stages?

7. Briefly discuss the mayfly life cycle. Stress the significance of the mayfly nymph stage of the life cycle. Why would you think the nymph is so sensitive to pollution?

8. Briefly discuss the ***Mayfly's role in the food web***. How would the disappearance of the mayfly affect other animals in the food web?

9. Now that the students have background information about mayflies and their life cycle, should they be concerned about mayflies? Review: ***Why should we be concerned about mayflies?***

10. **Group activity:** Have students form several groups. Have each group develop a list of ways it affects the water around them. Have them brainstorm about what steps they can take to change the water quality and make a difference? Have them think about what they would they do if the bay became so polluted that they didn't have any clean water to drink or use for bathing?

11. **Tying it all together:** Mayflies are an important component of the ecosystems of Presque Isle Bay and Lake Erie. Because they are sensitive to pollution, they can be used as one indication of the quality of the water that we all depend on. By controlling and preventing point and nonpoint source pollution, the mayflies stand a better chance of survival and so does the rest of the ecosystem, including us.

12. Pass out student worksheet: Mayflies on the Move!

VOCABULARY

Nonpoint source pollution
Point source pollution
Water quality indicator species
Nymph
Exoskeleton
Potable water

QUESTIONS/INQUIRY

- ✓ Using data collected by Pennsylvania Sea Grant and historic records, compare and contrast mayfly population from previous years. Hypothesize what the conditions might have been when mayflies were abundant in previous years as compared to the present situation?
- ✓ Do you think mayfly populations are related to the fish populations?

ASSESSMENT

- ✓ Students should be able to correctly identify and describe a mayfly from a group of similar insects. What do they have in common? What are their differences?
- ✓ Students will be able to articulate (written or orally) how the mayfly population relates to the local fish population and why? And how do local environmental factors impact the mayfly population?
- ✓ Students will be assessed for the completion and correctness of their worksheet.

GLOSSARY

Nonpoint source pollution: Pollution that results from runoff of melting snow or rainwater picking up pollutants as it is carried to streams and lakes. These pollutants consist primarily of sediments and nutrients but can carry bacteria, viruses, oils, grease, toxic chemicals and heavy metals.

Point source pollution: Pollution that originates from a specific identifiable source such as a pipe from a factory. Other sources could be discharge from wastewater treatment plants, or other industrial sources.

Water quality indicator species: A species that is environmentally sensitive to pollution. Mayflies are an indicator of good water quality.

Nymph: The interim stage of development, between egg and adult, among insects that undergo incomplete metamorphosis.

Exoskeleton: The outside covering of the body of an insect or spider or other arthropods.

Potable water: Water that is clean and can be used for drinking, bathing, or other uses.

REFERENCES

- ✓ Krieger, K. A. 1997 Mayflies and Lake Erie: A Sign of the Times. Ohio State University Sea Grant Fact Sheet FS-069, Columbus, Ohio.
- ✓ Mayflies Return to Lake Erie. Pennsylvania Sea Grant Fact Sheet 99-01. Erie, PA.
- ✓ Kentucky Water Watch: Water Resource Monitoring. http://www.state.ky.us/nrepc/water/group1.htm

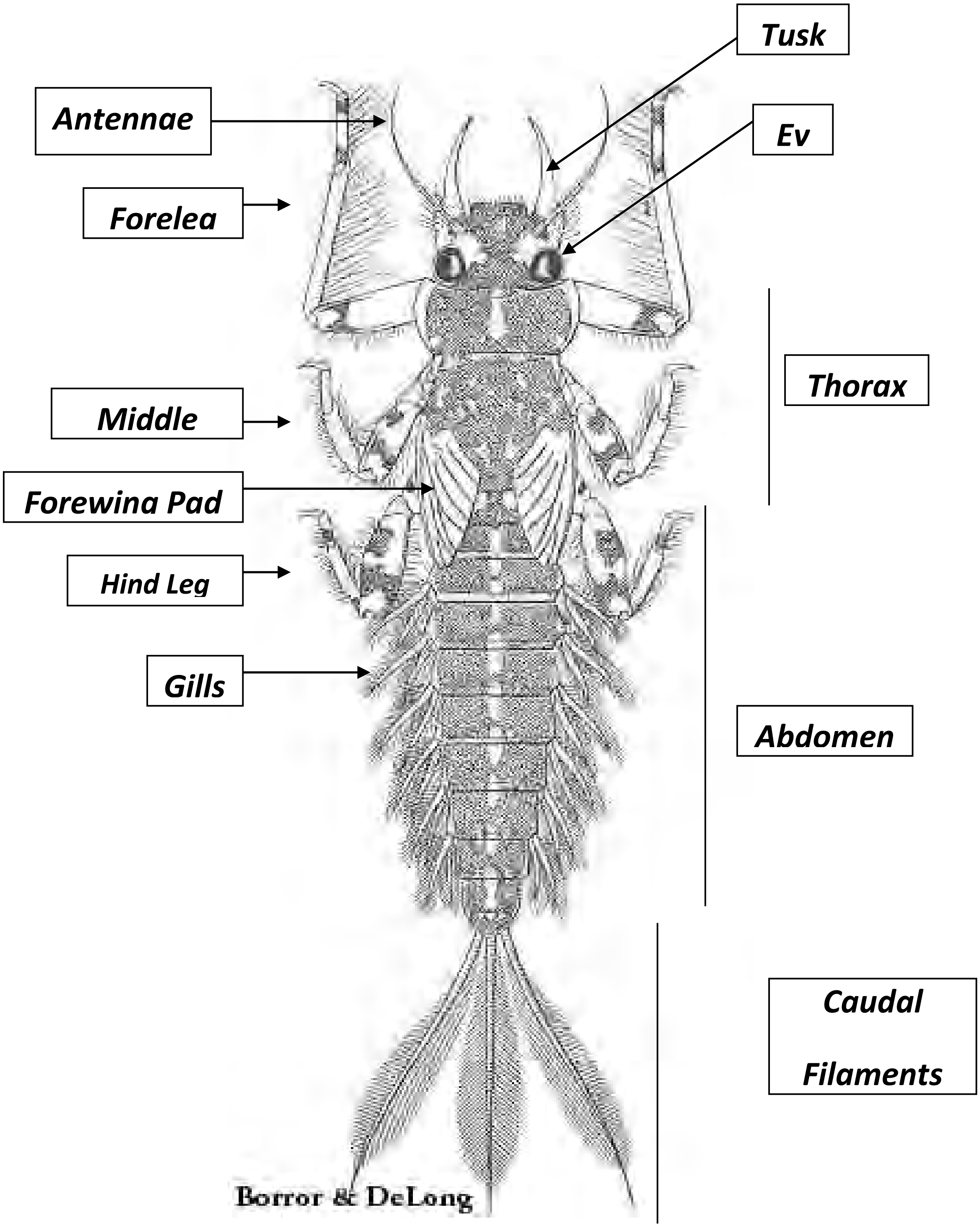
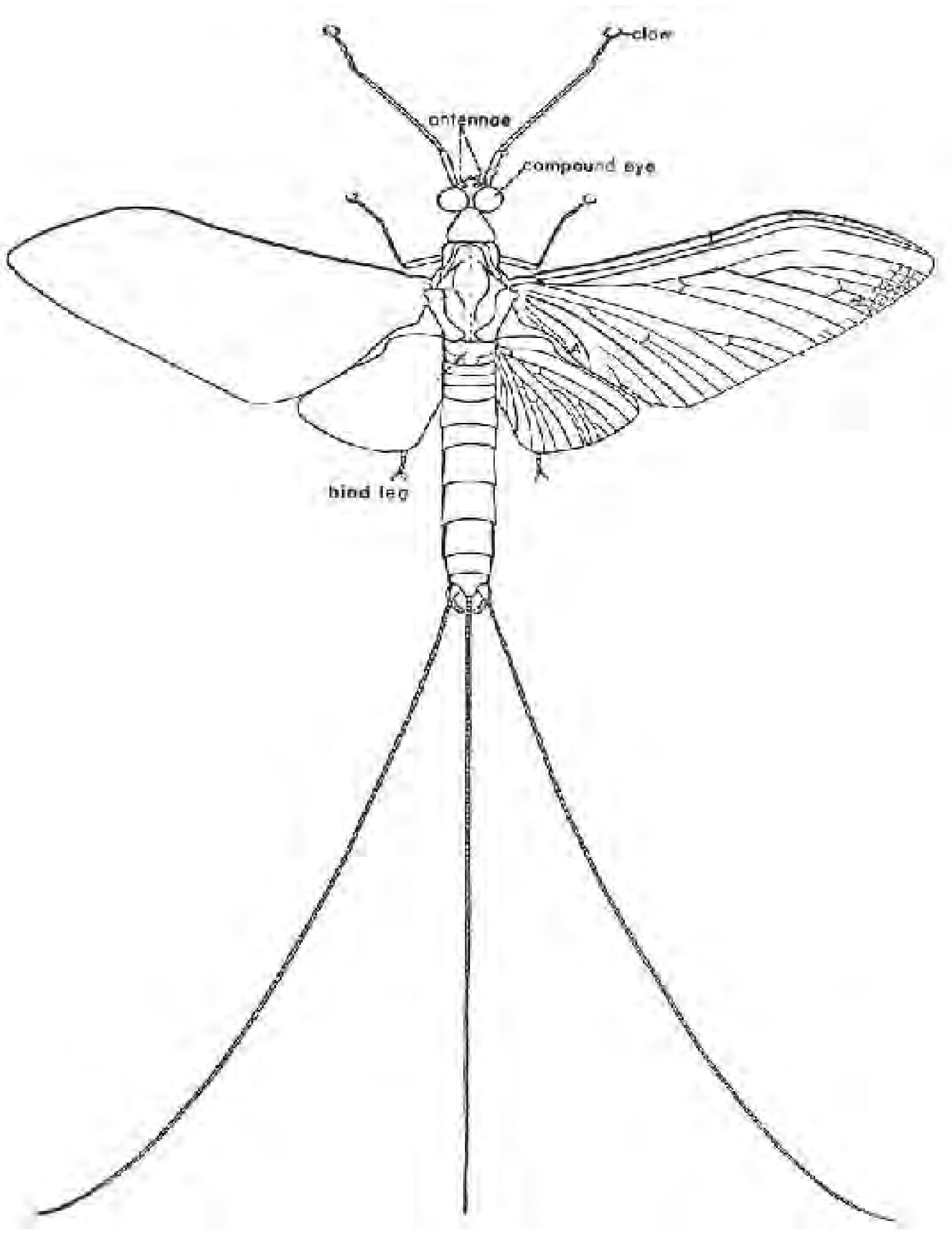
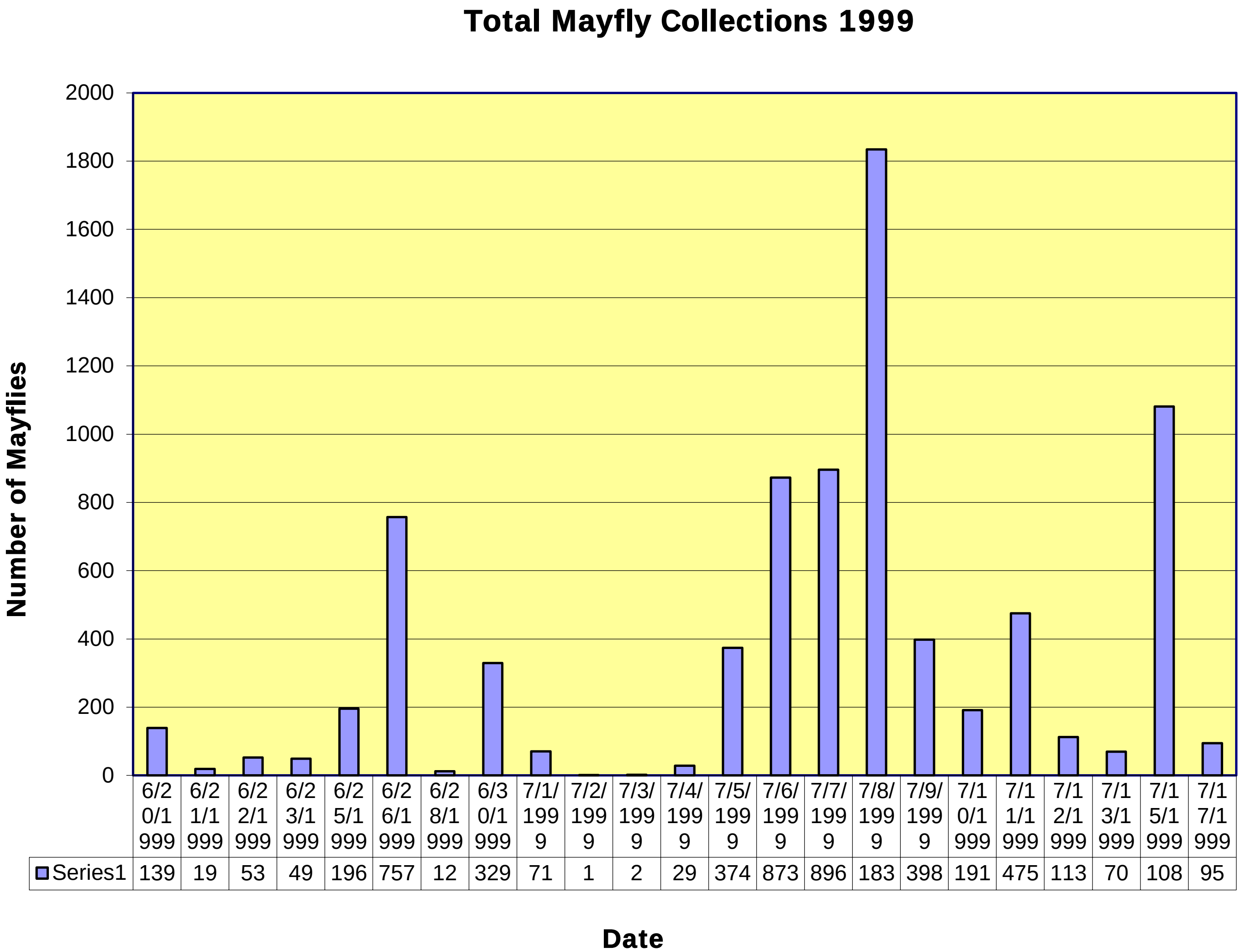


Figure 1: Mayfly Nymph

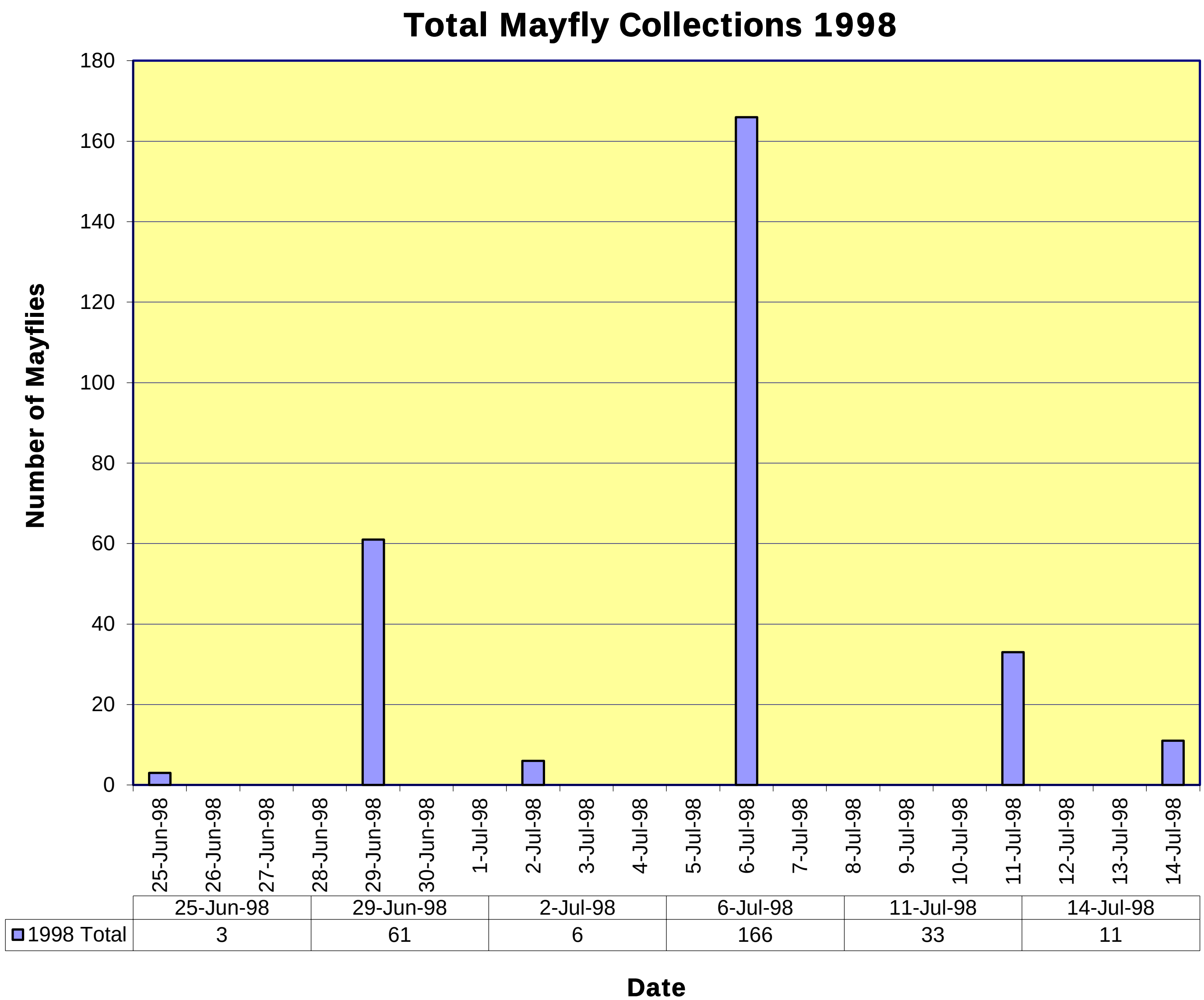


Burks, 1953

Figure 2: Mayfly Adult



	6/20/1999	6/21/1999	6/22/1999	6/23/1999	6/25/1999	6/26/1999	6/28/1999	6/30/1999	7/1/1999	7/2/1999	7/3/1999	7/4/1999	7/5/1999	7/6/1999	7/7/1999	7/8/1999	7/9/1999	7/10/1999	7/11/1999	7/12/1999	7/13/1999	7/15/1999	7/17/1999
Series1	139	19	53	49	196	757	12	329	71	1	2	29	374	873	896	183	398	191	475	113	70	108	95


Total Mayfly Collections 1998
Number of Mayflies
Date
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20
40
60
80
100
120
140
160
180
25-Jun-98
26-Jun-98
27-Jun-98
28-Jun-98
29-Jun-98
30-Jun-98
1-Jul-98
2-Jul-98
3-Jul-98
4-Jul-98
5-Jul-98
6-Jul-98
7-Jul-98
8-Jul-98
9-Jul-98
10-Jul-98
11-Jul-98
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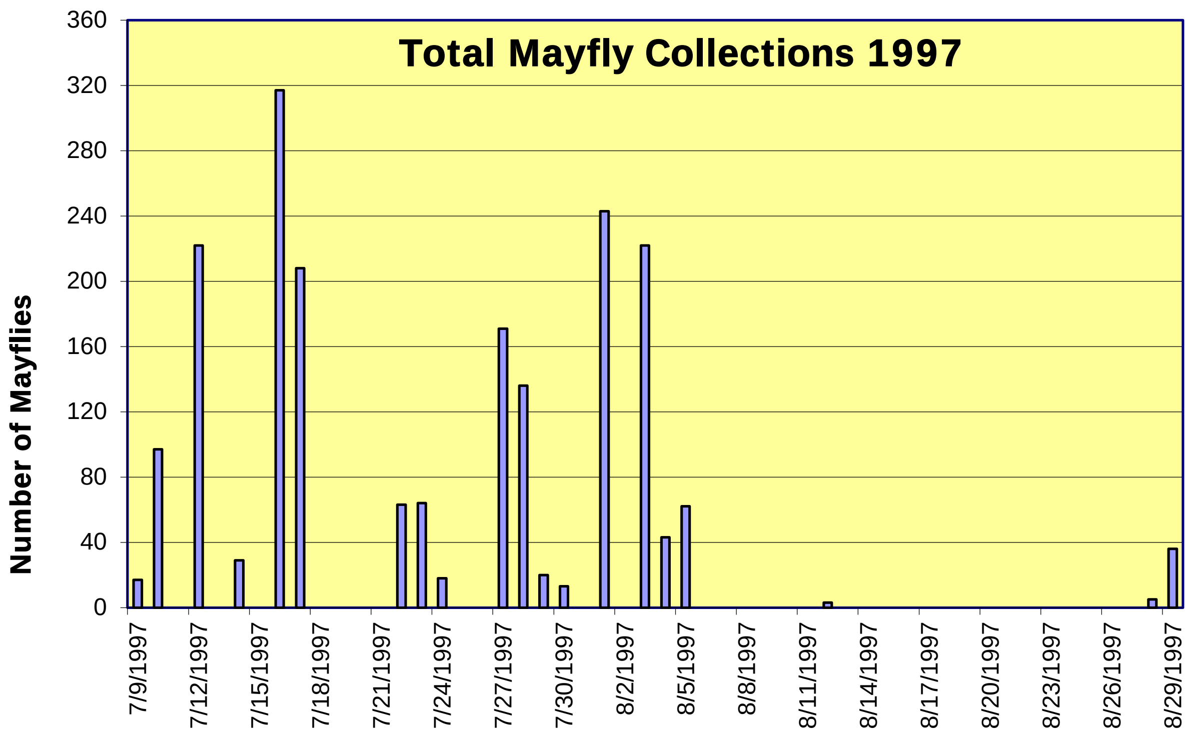
1998 Total 3 61 6 166 33 11



	9-Jul-97	10-Jul-97	12-Jul-97	14-Jul-97	16-Jul-97	17-Jul-97	22-Jul-97	23-Jul-97	24-Jul-97	27-Jul-97	28-Jul-97	29-Jul-97	30-Jul-97	1-Aug-97	3-Aug-97	4-Aug-97	5-Aug-97	12-Aug-97	28-Aug-97	29-Aug-97
Series1	17	97	222	29	317	208	63	64	18	171	136	20	13	243	222	43	62	3	5	36

Date

GRADE LEVEL/SUBJECT
Grade 7:
Ecology/History/
Environmental Science

TIME Two Class Periods

OVERVIEW Presque Isle is a recurved sand spit that was formed over 14,000 years ago when a massive glacier retreated and left a deposit of sand and gravel. Since that time, humans have taken advantage of such a unique and delicate region. From the Iroquois Indians in 1650 to Commodore Oliver Hazard Perry in the Battle of Lake Erie, to the present day opportunities offered by Presque Isle State Park, Presque Isle truly is a natural wonder to be appreciated and preserved.

PURPOSE The purpose of this lesson is to educate students about the origin, history and ecology of Presque Isle, so they are better able to appreciate its uniqueness to our region.

OBJECTIVES
At the end of this lesson the students will be able to:
- ✓ State how Presque Isle has evolved and changed over time.
- ✓ Recount Presque Isle's role in the War of 1812 and Battle of Lake Erie.
- ✓ List the stages of ecological succession and relate them to the biodiversity of Presque Isle.

RESOURCES/MATERIALS
Map of Presque Isle State Park/Presque Isle Bay
Pennsylvania Trails of Geology booklet
Worksheet for each student
Computer with Internet access-optional

PRIOR KNOWLEDGE
War of 1812
Concept of ecological succession

MOTIVATION
- o Who likes to go swimming? Who likes to in-line skate, ride their bike, or go hunting or fishing?

- How many of the students have ever visited Presque Isle or been on Presque Isle Bay?
- Ask students what they know about Presque Isle. Make a list.

BACKGROUND INFORMATION

Note: *For* more in- depth information on the origin and migration of Presque Isle, refer to the *Trails of Geology* brochure*.*

Origin of Presque Isle

Note: Refer to *Trails of Geology* page 2

Presque Isle, French for "almost an island", is a recurved sand spit that was formed more than 11,000 years ago according to geologists. On a geologic time scale this is a very short time. This peninsula was formed as a result of a glacial deposit called a **moraine**, which consists of particles of sand, clay and gravel. The glacier that formed the moraine across Lake Erie was a late, minor advance of the last major ice sheet that covered much of northern Pennsylvania. Approximately 13,000 to 14,000 years ago, the small glacier moved southward into the valley now occupied by Lake Erie (Figure 1). This moraine marks the location where the glacier stopped, and was left behind as the ice melted away.

Migration of Presque Isle

Note: Refer to *Trails of Geology* page 3,6,12

Throughout its 11,000 year history, Presque Isle has been anything but stationary. During the last several hundred years, wind and wave action have acted on this fragile sand spit and have progressively moved it eastward (Figure 2). The formation of the spit is controlled by the relative intensity of erosion and transport and deposition of the sand into different areas on the peninsula. Presque Isle has been an island several times. In 1819 the westerly winds and accompanying wave action broke through the neck of the peninsula and separated the peninsula from the mainland. Its longest span as an island was from 1833 to1864. The gap occurred as a result of wave action and remained open for 32 years, until it was filled in by natural **siltation**.

Refer to *Trails of Geology* page 12
A variety of efforts have been used to keep Presque Isle from migrating eastward. In order to protect and maintain the beaches, bars and dunes on the park, man-made structures have been placed along the shorelines to provide protection from erosion. Examples of these structures include groins, seawalls and detached breakwaters. Refer to Trails of Geology for descriptions of each type. Beach nourishment has also been used to combat erosion.

History

Presque Isle was discovered and named by the French in the 1720s. The name Presque Isle was later translated into English to mean "almost an island." Before that time there was evidence that the first users of the protected waters of Presque Isle were Indians. The Eriez Nation inhabited the Lake Erie shoreline giving Lake Erie and the city of Erie its name. The Eriez were thought to have been an agricultural people who used the land on Presque Isle for farming and settlement.

First Settlers

Presque Isle has seen many settlers come and go since the Iroquois of 1650. Since Presque Isle Bay was a natural harbor, the French used it for protection from attack by the English. Between 1720 and 1759, the French established two military outposts on Presque Isle to protect them from the invasion of the English. Both posts were believed to be made of brick; one thought to be at the easternmost tip of the Peninsula and the other at the neck of the peninsula. Following their defeat by the British in the French & Indian War, the French destroyed their fort on the mainland near the mouth of Mill Creek and subsequently abandoned their claims to northwest Pennsylvania.

The War of 1812

A dispute arose over who should take ownership of the Erie Triangle, which encompasses the northern half of Erie County and the peninsula. In 1792, Pennsylvania was able to purchase this land from the federal government, but it wasn't until 1795 when Anthony Wayne defeated the western Indians that the Americans could permanently settle in this region. This defeat marked the true end of the American Revolution. General Anthony Wayne was headed back to Pittsburgh in December of 1796 and became ill with gout. He died on December 16, 1796 in the Erie Blockhouse and was buried beneath the flagpole. The blockhouse was originally built in 1795 and served as one of the first outposts in the post-Revolutionary War era. Today, the Anthony Wayne Blockhouse stands as a memorial to General Anthony Wayne and is located at the foot of Ash Street in Erie, Pennsylvania.

The War of 1812 brought much activity to Presque Isle State Park. The park harbored a naval base during the war and it was here that Commodore Oliver Hazard Perry built his ships and trained his men for battle. On September 10, 1813, the British and American fleets clashed in a battle on Put-in Bay, (near Sandusky, Ohio) that was the turning point in the War of 1812. Following the defeat of the British, Perry returned with his fleet to Presque Isle and built a bunkhouse and storage building at Misery Bay. Six of his nine vessels, including two

brigs (the *Niagara* and the *Lawrence*) were constructed in the bay using trees most likely from the peninsula. During the cold winter of 1813-1814, many of Perry's men suffered from smallpox and were quarantined in Misery Bay. Many of the men who died were buried in a neighboring pond, which is now named Dead Pond.

Preserving the Fleet In 1814, the hull of two of Perry's ships, the *Niagara* and the *Lawrence*, were sunk in Misery Bay in an effort to preserve them. They were raised again in celebration of the centennial of the war (at right). When the *Lawrence* was raised, it was in such disrepair that it was sold for souvenirs. The *Niagara* was sunk again later to be raised and **restored.**

Development of a State Park

The uniqueness of Presque Isle was recognized and much effort went into protecting the peninsula. In 1921, for the purposes of creating a state park, Pennsylvania acquired full ownership of Presque Isle State Park. This began the most intense development period in the history of the park. The first paved road in the park was built in 1924. This road allowed visitors a better view of the lake. During the years that followed, many structures were built such as cabins, picnic pavilions, the Nature Center, boat liveries, and others. These improvements attracted many more visitors. The 1950s brought more people and major changes to the park. The neck of the peninsula was widened with the addition of 3,000,000 cubic yards of sand taken from Long Pond located on the park. This removal of the sand created an inland lake for the marina that still exits today. The neck was now large enough to accommodate a one-way traffic system with off street parking and beach facilities. In 1957, three modern bathhouses were constructed. Today, Presque Isle State Park has grown tremendously and today provides recreational opportunities for its over 4 million annual visitors. Some of these recreational opportunities include hiking, biking, boating, hunting, fishing, picnicking, and a multipurpose trail. Other events that take place on the park are bicycle, running and cross country ski races, and Discover Presque Isle.

Ecology of Presque Isle

Presque Isle has a unique ecosystem. Presque Isle's diversity of habitats gives it a high level of **biodiversity**. The biodiversity of Presque Isle is represented by over 640 species of plants, 325* species of birds, 50 species of mammals, 31 species of reptiles and amphibians, and thousands of invertebrates, including 84 different spiders, and 35 different butterflies. **Succession** can be thought of as the sequence of changes that take place in a community following some disturbance to the environment such as flood, fire, or human activities. You can witness these ecological changes and experience over 600 years of ecological succession simply by walking from the beaches to the climax forest. These changes are represented by six distinct ecological zones, each with different plant and animal **communities** (Table 1). Each of these distinct zones provide unique physical environments for animals called **habitats** and **niches**. These six zones are Lake Erie the bay and shoreline;

sand plain and new ponds; dunes and ridges; old ponds and marshes; thicket and sub-climax forest; and climax forest.

Ecological Stages of Succession

Why do these zones exist? The major factors that create these zones are the wind and wave action of Lake Erie acting on the beaches of Presque Isle.

Stage One: Water's Edge, Drift Beach and Upper Beach

The first stage of succession occurs where the Lake Erie waters meet the beaches of Presque Isle. Wind and wave action hit the sandy beaches at an angle and cause **erosion** and redeposition of the sand to the east (recall from "Migration of Presque Isle.") The newly formed beaches are very unstable for a time until vegetation is able to take root. Once the vegetation is established, and the sand is stable the scene is set for stage two.

Stage Two: New Dunes, New Ponds and Sand Plain

Over time, the sand that was moved by the wind and wave action begins to move farther inland out of reach of these elements. As the eastern moving sand is redeposited at the tip of the peninsula, the water that was beating the shoreline gets enclosed as a pond. This pond is not likely to be permanent because the windblown sand may be washed away, build up around the base of trees, begin to form dunes or fill in the ponds. If the pond survives these natural occurrences, plants and wildlife will slowly appear. This sets the scene for the next stage of succession.

Stage Three: Fore Dunes, Back Dunes and Ridges

Sand is continually carried inland from the beaches where it is blocked by vegetation. As the sand continues to build up around the base of trees, it starts to form small dunes. As the sand continues to pile up, dune grasses begin to colonize. As the vegetation and dunes grow, more and more sand accumulates. The new vegetation and sand creates habitat for many types of birds and mammals. The ridges present on Presque Isle are actually examples of long, old dunes that represent shorelines of the past. The ridges were formed from prevailing west winds building up sand parallel to the shoreline. Long Pond (refer to park map) located one half mile inland from the east shore provides evidence of waves crashing against the shore in 1862.

Stage Four: Old Ponds and Marshes

Surrounding the ponds are dunes and ridges that provide barriers from the wind, allowing the ponds to develop into a stable habitat for many species of plants and animals. The many years in which it took to form this habitat allows for a high level of biodiversity. This high biodiversity spans the entire area of the pond from the water's edge to the open waters. As the pond ages, various types of vegetation can be used to determine its age. When the vegetation at the edges of the pond accumulates soil and debris, along with the growth of heavy algae on the surface of the pond, a **marsh** slowly begins to develop and the pond slowly dies due to the lack of light and oxygen. Over time, some marshes will begin to dry out from the build up of dead vegetation. This leads to the next stage in ecological succession.

Stage Five: Thicket and Sub-Climax Forest

A thicket begins to form when dense, shrubby vegetation begins to grow on a drying marsh. Seeds from various trees are carried by the wildlife or blown by the wind into the thicket and begin to grow. As these trees grow they provide shade which prevents the thicket from growing further and thins the shrubby undergrowth called the sub-climax forest. The border between the thicket and the sub-climax forest forms the **edge habitat**. This habitat provides protection from predators for wildlife that travel between the sub-climax forest and the thicket. Larger trees eventually colonize the sub-climax forest and grow very tall, creating a large **canopy**. This canopy changes the nature of the vegetation growing under the trees. The sub-climax forest is then transformed into the final stage of ecological succession: a climax forest.

Stage Six: Older and Climax Forest

After years of slow change, the sub-climax forest is transformed by the growth of many trees into a climax forest. The term "climax forest" suggests that if nature is left alone without human or natural disruption, the more prevalent trees will persist for many years. The large stand of trees provides a lot of shade and also a diversity of habitats for animals and plants. Some animals find shelter in the niches produced by the layers of trees, others inhabit the forest floor. Many of these same animals would not be able to survive without the canopy of the forest. Found in the interior of the park, the climax forest is the oldest region providing evidence of history and movement of succession stages.

Human Impacts on Natural Succession

Human disruptions can positively or negatively affect the natural succession process seen on Presque Isle State Park. Our need for access to recreation on the park has led to an elaborate system of roads, parking lots, and buildings. These structures cannot exist if the sand underneath them moves. Efforts to protect Erie and its harbor from lake storms sometimes conflict with the natural system of moving sand. New construction can create barriers for plants and wildlife. For example, plants cannot grow on the asphalt roads and water is not absorbed like it is by soil. Therefore, the water runs off and causes erosion. Roads also can cause **fragmentation** of a larger habitat into smaller ones. This makes it difficult for animals or plants that need large areas of habitat. It is important to realize that everything that humans do to an area will affect it either negatively or positively. This is why it is so important to understand the processes of succession so that we are better able to preserve and protect the uniqueness of Presque Isle.

Gull Point: A Haven for Birds The most understood and widely studied of all the animals on Presque Isle are the birds. The diversity of habitats makes Presque Isle a haven for migrating and resident birds. Over 325 species of birds have been found on Presque Isle at one time or another throughout the year, however not all 325 species are year round residents to the park. Located at the tip of Presque Isle, Gull Point is a perfect stop for migrating birds. Migrating shorebirds flying north arrive in April and stop to rest before flying over the lake. They use Presque Isle once again as their rest stop when flying south in November. Each year shorebirds migrate from beyond the Arctic Circle to the southern reaches of South America and back again. Presque Isle is located along the **Atlantic Flyway** (at right). About 67 acres of Gull Point have been set aside as a special management area in hopes of allowing rare and migratory shorebirds to nest, rest, and feed successfully. Because of this, Gull Point is closed to all public use from April 1 to November 30.

PROCEDURE:

Origin of Presque Isle

1. Display Presque Isle State Park map to class.
2. Display Figure 1 to show relationship of Presque Isle to Lake Erie and other Great Lakes.
3. Hand out *Trails of Geology* booklet. Review the information given about Presque Isle's origin.
4. Discuss with students the relationship between glaciers and Presque Isle's formation.

Migration of Presque Isle

1. Refer to *Trails of Geology* booklet.
2. Discuss how sand is transported by wind and wave motion and how that relates to Presque Isle's migration over the past several hundred years.
3. Handout Figure 2 (Migration of Presque Isle 1790-1971.) Point out the differences over the years. In which direction did it move since 1790? Has the size of it changed?
4. Review information on page 12 of *Trails of Geology* booklet about how manmade structures have been placed on the park in order to protect Presque Isle. Point out structures on the park map. Discuss the effectiveness of these structures and how they prevent erosion of the beaches.

History

1. Review the information given about Presque Isle's history.
2. Discuss the role that Presque Isle played in the Battle of Lake Erie and the War of 1812.
3. Review the information given about the development of Presque Isle as a state park.
4. Discuss the changes that have taken place from the time the park was first established to the present day. List the major changes on the chalkboard. What are the impacts of these changes on Presque Isle?

Ecosystem

1. Display Table 1 (Inventory of Wildlife and Plants) to students.
2. Review the information given about Presque Isle State Park's ecosystem.
3. As you discuss each stage of succession, ask the students to describe or list the changes that they see in plants and wildlife through the stages. Make a list on the chalkboard.
4. Refer to Table 1 and compare the diversity of each stage. Is there higher diversity in certain habitats? Why?
5. Pass out student worksheet: Presque Isle

VOCABULARY

Atlantic Flyway
Biodiversity
Community
Ecological Niche
Ecological Zones
Ecosystem
Fragmentation
Habitats
Moraine
Siltation
Succession

QUESTIONS/ INQUIRY

HISTORY/ CREATIVE WRITING:

Students will write what they would have done if they were the first settlers on Presque Isle in the 1600s. Have them list what Presque Isle looks like in terms of the wildlife, plants etc. Are there a lot of trees or deer? Are there any other settlers there with you?

ECOLOGY GROUP ACTIVITY:

To give students a better understanding of the ecological stages of succession, split the class up into six groups. Each group will represent a different stage of succession. Each student will be responsible for knowing what type of habitat their groups' stage represents as well as the types of plant and wildlife are characteristic of their stage. Students should also provide a brief history of how their stage fits into the six stages of ecological succession and how their stage originated. Students should list what possible impacts humans could have on their stage if they were to disrupt it by construction.

ASSESSMENT

- ✓ Students will be assessed on their participation in the ecology group activity. Students should be able to describe the characteristics of their ecological stage of succession and how it relates to the other five stages.
- ✓ Students will be assessed for the completion and correctness of their worksheet.

GLOSSARY

Atlantic Flyway: The route that migrating birds follow on their journey to their wintering/breeding grounds.

Biodiversity: A measure of the variety of living things in a community, based upon one of several mathematical formulae, which account for both numbers of species and numbers of individuals within species. High diversity results from high numbers of species and an even distribution of numbers within species. Stressed environments generally have low diversity.

Canopy: The high covering in a forest formed by the upper leaves and branches of trees.

Community: A group of species that live in the same area.

Ecological Niche: The way a species 'makes its living'; where it lives, what it consumes, and how it avoids consumption by predators or displacement by other species.

Edge Habitat: Unique habitat bordering a forest's or thicket's edge and grassland or marsh.

Ecosystem: A natural system including the sum total of all living things, the non-living environment and its physical forces; and the relationships among these, including processes such as predation, competition, energy flow, and nutrient cycling. Presque Isle is an ecosystem.

Erosion: The natural processes of wearing away of the earth's surface by floods, glaciers, waves or wind.

Fragmentation: The division of a large habitat into small sections.

Habitat: The environment in which a species lives in, providing life requirements such as food and shelter.

Marsh: An ecosystem that has the qualities of land and water. Example: swamps

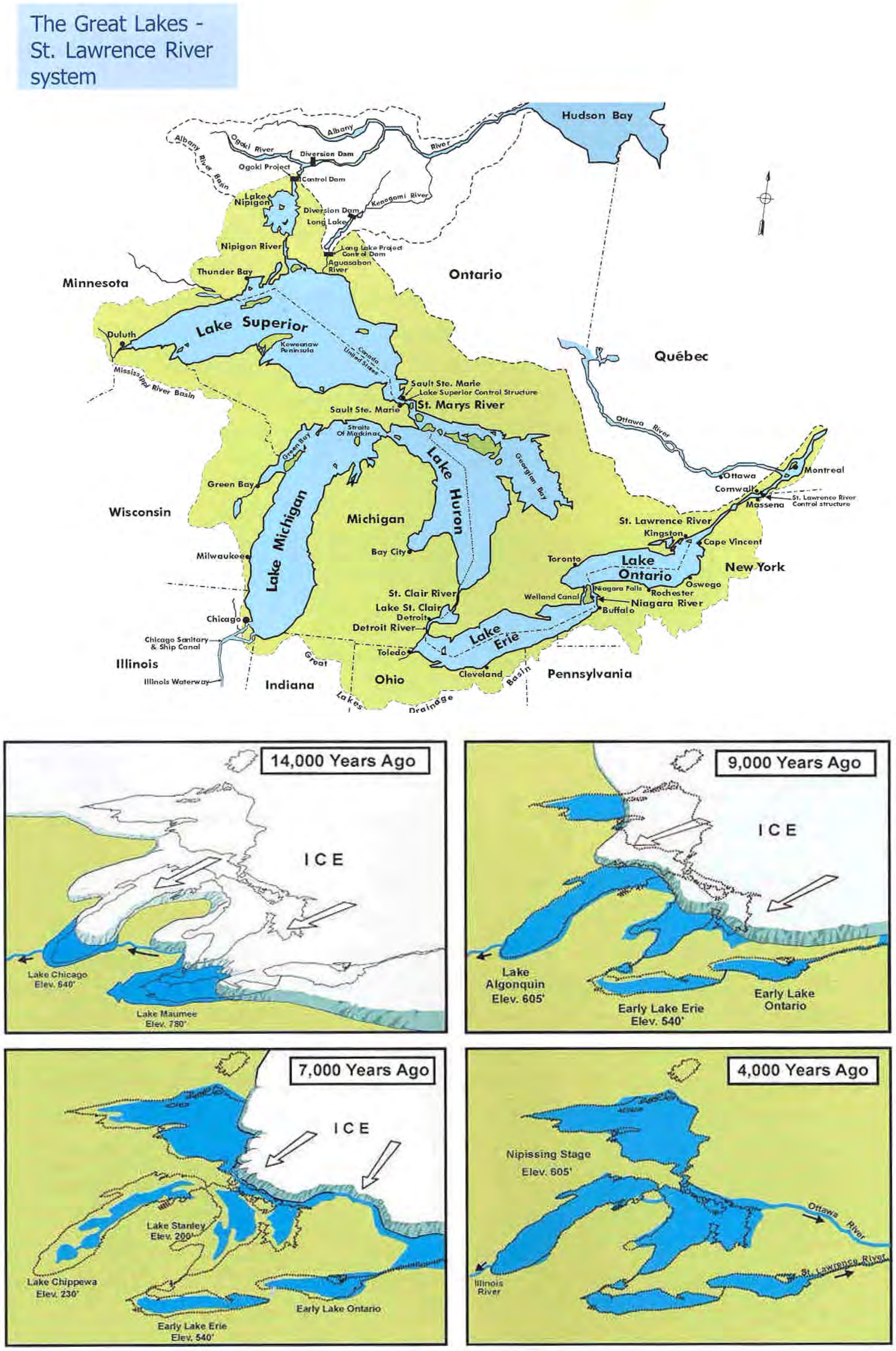
Moraine: A ridge of sediment that consists of clay, sand and gravel that is carried by huge bodies of slowly moving ice, called glaciers.

Siltation: The accumulation of sediments transported by water.

Succession: Stages of growth that take place if allowed to develop undisturbed.

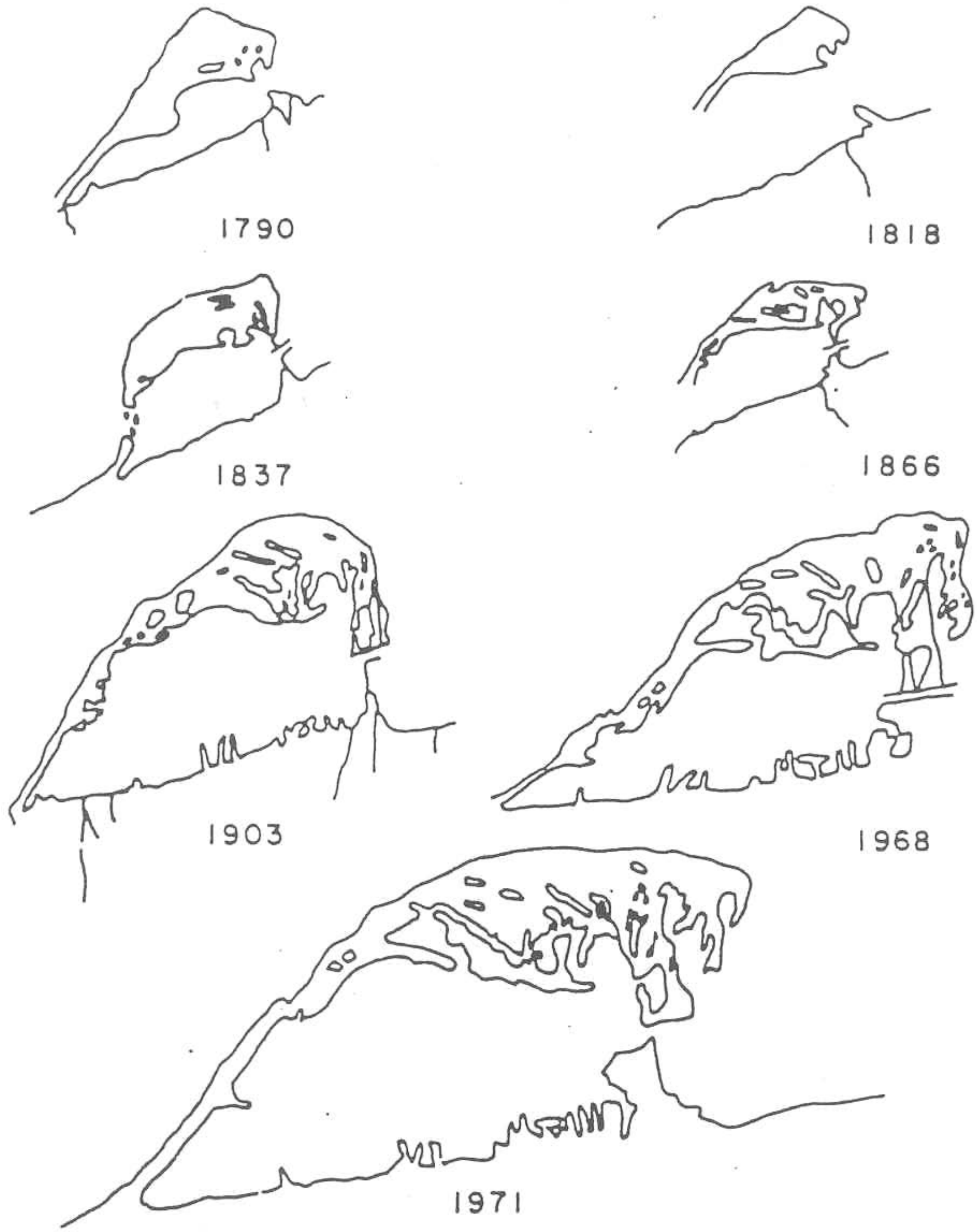
REFERENCES

- ✓ Presque Isle State Park Home Page:
- ✓ http://www.dcnr.state.pa.us/stateparks/presqueisle
- ✓ Resource Management Plan Presque Isle State Park; Commonwealth of Pennsylvania, Department of Environmental Resources, Office of Parks and Forestry, Bureau of State Parks; May 6, 1993.



Prehistoric glacial movements and lake shapes

Figure 1: Formation of the Great Lakes



Source: U.S. Army Corps of Engineers.

Figure 2: Migration of Presque Isle

INVENTORY LIST OF WILDLIFE AND PLANTS FOUND IN SUCCESSIONAL STAGES

	Water's Edge and Beach	New Pond/Sand Plain	Back Dunes/Ridges	Old Pond/Marshes	Thicket/Sub-Climax Forest	Older/Climax Forest
Vegetation	Sea Rocket Sun/Beach Spurge Beach Clotbur Mugwart Clammy Cudweed Common Evening Primrose	Cottonwood seedlings Umbrella Sedge Bayberry Beach Pea Cyperus Spurge Phragmites Lubgrass Japanese Honeysuckle American three square	American Beach grass Switch Grass Cottonwood Audits Mugwart Ground Nut Riverside Grape Cyperus Spurge Choke Cherry Poison Ivy	Cattails Sedges Bulrushes Willows Blueflag Swamp Rose Mallow Fragrant Waterlily Tufted Loostrife	Poison Ivy Bittersweet Wild Grapes Wild Cherries White Pine Red Maple Mayapple Starry False Solomon's Seal Orchids	Hemlock Red Maple Black Oak Red Oak Fern Moss Black Cherry White Ash Choke Cherry
Birds	Ring Billed Gull Sanderling Pipping Plover Ruddy Turnstone	Eastern Bluebird Redwinged Blackbird Great Blue Heron Mallard	Yellow Rumped Warbler	Marsh Wren American Bittern Red Winged Blackbird	Finch Cardinal Wood Thrush	Great Horned Owl Red Headed Woodpecker Piliated Woodpecker Crow
Mammals			Fox Coyote	Muskrat Beaver Wood Duck Black Duck	Cottontail Rabbit Raccoon Virginia Opossum White Footed Mouse White Tailed Deer	Red Bat Little Brown Bat Fox Squirrel
Reptiles		Map Turtle Northern Water Snake	Garter Snake	Snapping Turtle Northern Brown Snake Map Turtle Painted Turtle	Black Rat Snake	Box Turtle
Amphibians		Spring Peeper		Bullfrog	American Toad Spotted Salamander	Eastern American Toad
Invertebrates	Wolf Spider	Dragonfly	Monarch Butterfly	Mosquito	Luna Moth Tent Caterpillar	Paper Wasp Ladybug Termites
Fish		Bluegill		Sunfish Carp		

Table 1: Inventory of Wildlife and Plants

PRESQUE ISLE BAY:

AREA OF RECOVERY (AOR)

GRADE LEVEL/SUBJECT
Grade 7: Ecology/Environmental Science

TIME Two Class Periods

OVERVIEW Presque Isle Bay is located along the Pennsylvania shores of Lake Erie, and provides the City of Erie with a protected harbor. The bay is widely used for recreational boating activities and is also a regular recipient of runoff, industrial discharge, sewage effluent, and other toxic pollutants from the City of Erie. In 1991, Presque Isle Bay was designated the 43rd Area of Concern (AOC) due to its contaminated sediments and incidence of tumors on brown bullheads. Because of this designation, numerous organizations in Presque Isle Bay and its tributaries began to take action to develop studies on the issues going on in Presque Isle Bay. Because of their hard work, in 2002 Presque Isle bay became the very first Area of Recovery (AOR) in the Great Lakes.

PURPOSE The purpose of this lesson is to introduce students to Presque Isle Bay and to inform them as to why it was named an AOC and what impact it had on the Erie community.

OBJECTIVES
At the end of this lesson students will be able to:
- ✓ Define what an AOC is.
- ✓ State ways that designation as an AOC affects the ecosystem of Presque Isle Bay.
- ✓ State ways that designation as an AOC affects the Erie community.
- ✓ Understand the effect that sources of point and nonpoint pollution have on Presque Isle Bay.
- ✓ Identify steps they can take to make Presque Isle Bay a cleaner environment.

RESOURCES/MATERIALS
Map of Presque Isle State Park/Presque Isle Bay
Topographical map of Presque Isle Bay watershed
Worksheet for each student
Computer with Internet access-optional

PRIOR KNOWLEDGE

Concept of watersheds
Point and nonpoint source pollution

MOTIVATION

- Who washes their family car in the street in the summer?
- Who likes to swim at the beaches on Presque Isle?
- Who likes to fish?

BACKGROUND INFORMATION

Presque Isle Bay

The Presque Isle ecosystem contains an ecological resource that is unique within the state and rare within the Great Lakes basin. Covering approximately 3,718 acres, Presque Isle Bay is formed by a natural sand spit to the north. It is a shallow embayment with an average depth of 13 ft. The bay is a relatively sheltered body of water that has a restricted exchange of water with its outer harbor and Lake Erie. Because of this, the bay has a "**flushing time**" of almost 2.5 years, short in comparison to Lake Superior, with a flushing time of 191 years. This long time period allows the pollutants entering the bay as runoff to settle in the primarily fine and organically rich bottom sediments. However, large rocks and sand persist in certain areas where currents have restricted the settlement of finer sediments. The animal and plant population of Presque Isle Bay consist of different types of fish, birds, plants and mammals. Some examples of fish include yellow perch, bluegill, rock bass and, largemouth bass.

What is a watershed?

Humans need water for drinking, irrigation and industry, yet we have a very casual attitude toward water pollution. Every day, wastes are poured down the sink, flushed down the toilet, or dumped into rivers and lakes without ever considering where they will end up. We all depend on Lake Erie as a water supply so we can take our shower in the morning and wash our dishes at night. Much of the water we use comes from Presque Isle Bay and Lake Erie. And they both depend on the network of streams or **watershed** that replenishes their water.

A watershed, also known as a drainage basin, includes the entire land area drained by a particular creek or river. Precipitation that falls in this area runs off as surface water into a stream channel, lake, reservoir, or other body of water. Stand along any stream and look upstream. All of the water flowing in that stream has fallen on an area of land, which by the nature of its topography, has caused the water to drain to that particular point of the stream. The area that drains to that point is called the stream's watershed.

The topography of the land determines the boundaries of the watershed. These boundaries are the highest points and ridges surrounding a watershed and are called “divides”. The city of Erie is perched on an elevated lake plain (*Trails of Geology* page 5). Presque Isle Bay sits at the lowest point in the elevation of the plain. Further inland and at the higher elevations is the **drainage basin divide** (Map 1). This divide separates the Lake Erie Basin (streams that flow north toward the lake) from the Allegheny Basin (streams that drain south.) Streams in the Lake Erie Basin drain into either Lake Erie and/or Presque Isle Bay. Watersheds can range in size from the smallest mountain stream that drains only an acre of land to huge river systems such as the Susquehanna, which drains over 27,000 square miles. The Presque Isle Bay watershed spans approximately 25 square miles. It’s primary tributaries are Cascade Creek and Mill Creek, which together account for about two-thirds of the water flowing into the bay. Additional inflow of water comes from precipitation directly on the surface of the bay, **combined sewage outfalls** (CSO’s), groundwater discharge, and wastewater discharges.

Presque Isle Bay's watershed

Presque Isle Bay is the oldest U.S. Harbor on the Great Lakes, appropriated in 1824 from the national legislature for harbor improvements. The city of Erie, founded in 1792 has grown up around its port. Historically, Erie experienced the growth and decline of the steel industry in the U.S., together with its related heavy manufacturing. Much of the surrounding land has become urbanized with manufacturing industries that coexist with the residential and commercial neighborhoods. The surrounding watershed of Presque Isle Bay (See Topo map) is directly impacted by the use of this land. In the past, both industrial and domestic wastewater was discharged directly into the bay or into streams leading to the bay. At this time, many of the urban streams were looked at as sewers rather than as natural resources.

The main tributaries of Presque Isle Bay, Cascade and Mill Creek, account for two-thirds of Presque Isle Bay's water supply and receive runoff from the surrounding land and carry it directly into the bay. This urban runoff contains contaminants that affect fish and other aquatic life, drinking water, and recreation. Fertilizers and pesticides applied to agricultural lands and residential lawns can be carried into the streams after a rain event. The discharging of excess phosphorus and other nutrients that are in fertilizers can actually accelerate the natural aging process of the bay (eutrophication). This inflow of excess nutrients benefits some plants and causes them to overpopulate, harming other plants and animals living in the bay. When the excess aquatic plant growth dies and decomposes it uses up the available oxygen in the water. This decreases the amount of available oxygen for other aquatic organisms and many of them die as a result. The natural decay of plants and nutrients is called biodegradation.

Because 80 percent of the surrounding land use within the Presque Isle Bay watershed is urban, Presque Isle Bay receives high levels of nonpoint source pollutants from runoff. The most significant amount comes from residential areas.

Land developed with asphalt parking lots and buildings contribute oils and greases from cars that get into the surrounding streams after a rain event.

AOC Designation to AOR designation

This unique ecosystem of Presque Isle Bay has been subjected to pollution from both point and nonpoint sources (Figure 1). Because of this pollution, the U.S. Department of State designated Presque Isle Bay as the forty-third Great Lakes AOC in January 1991. The AOC designation is used to indicate severely degraded geographic areas within the Great Lakes Basin. A designation as an AOC has serious environmental implications. As an AOC, the bay received priority attention from the Pennsylvania Department of Environmental Protection to restore its impaired beneficial uses. The International Joint Commission (IJC) lists 14 beneficial use impairments for AOCs. A water body may be designated as an AOC if certain beneficial uses are determined to be impaired.

In Presque Isle Bay, the two impaired beneficial uses were: Restrictions on dredging of sediments, and fish tumors and other deformities. Since Presque Isle Bay's designation of an AOC, numerous organizations within the Bay and its' watershed decided to take action. They developed studies on the two beneficial use impairments present in Presque Isle Bay. Because of their hard work, in 2002, Presque Isle Bay was designated as the first Great Lakes Area of Recovery (AOR). In February, 2007, Presque Isle Bay delisted the restrictions on dredging beneficial use impairment; however, Presque Isle is still listed for having fish tumors. The fish tumors are thought to be related to elevated levels of organic contamination from nitrosamines or Polycyclic Aromatic Hydrocarbons (PAHs) in the sediments. Nitrosamines can be naturally produced in sediments when *anaerobic* (no oxygen) conditions exist along with an available source of excess nitrogen. Excess sources of nitrogen could come from sewage, fertilizers, or large fish kills. PAHs can come from the combustion of fossil fuels such as coal and petroleum. Other sources include asphalt and tar used to pave roads and parking lots and to waterproof the roofs of houses. PAHs are believed to have detrimental effects on the aquatic life in the bay.

Brown bullheads (at right), a member of the catfish family, live in Presque Isle Bay and have been found to have skin tumors and liver tumors. Scientists test the bile of the fish (located in the gall bladder) to look for the presence PAH metabolities. PAH metabolites are suspected to be the cause of liver tumors in the Presque Isle Bay brown bullheads. Research studies pertaining to Presque Isle Bay are reviewed by the Presque Isle Bay Advisory Committee (PAC). The PAC is comprised of representatives from local, state and federal agencies, environmental and civic organizations, academia and industry and was developed in order to identify the problems within the AOC and to develop remediation plans to correct them. Since its inception, the PAC has made considerable progress in improving the health of Presque Isle Bay.

Time, experience and change bring understanding

Today, we have a better understanding about the effects that pollution can have on the watershed of Presque Isle Bay. When you remember that even a small watershed can have a great impact on the entire drainage system downstream, you start to realize just how important it is to understand what is going on in the watershed area where you and your neighbors live. Understanding how our actions affect the environment will help us take action to change those activities that are detrimental to our environment.

PROCEDURE

1. Review information: **Presque Isle Bay**. Display map of Presque Isle Bay and point out the State Park, the City of Erie, Lake Erie and the channel. Ask the students how many of them can name any other bays. Comparing what they know about those bays, what do they think makes Presque Isle Bay unique?

2. How many of the students have a stream or creek by their house? When they wash their family cars or sprinkle their lawns with fertilizer where do they think all of the excess water containing those pollutants goes? Review information: **What is a Watershed?**
   Hint: To illustrate better the effect that pollution can have on the surrounding watershed, draw a sample watershed on the board so students can see how a watershed forms somewhat of a webbing pattern that leads to one common body of water (Refer to Map 1).

3. Ask the students to name any streams that they can think of that are in their neighborhood. Write the names on the board. Try and locate the stream on the map of the Presque Isle Bay watershed.

4. Review information: **Presque Isle Bay's watershed**. Display map of Presque Isle Bay watershed. Point out Cascade Creek, Mill Creek and Garrison Run.

5. Have students attempt to locate their street on the map so they see where they live in their watershed. What is the nearest stream located to their house?

6. Discuss with students what impact washing their cars in the street could have on the watershed. (*They might think that if they live in the city and are not close to a stream that they are not polluting the bay. Most don't realize*

where the water runs to after they see it disappear from their driveway. In many cases it disappears into the storm drains and eventually gets filtered and dumped into the bay.) Ask the students how many storm sewer drains are near their house?

7. Review information: **AOC Designation**. Ask students how they think Presque Isle Bay got this designation? Is this designation cause for concern? Would any of them go swimming in Presque Isle Bay? Why or why not?

8. Review information: **Time, experience and change bring understanding**. It is obvious that taking action has made a difference in protecting and restoring Presque Isle Bay. Ask students what they think they can do to make a difference? Have them make a list on paper.

   GROUP ACTIVITY: Students may form groups of five and work together to write down things they would do to change how we use and abuse our streams. Have them research local pollution incidents that have occurred in their neighborhood or school neighborhood. Put together a presentation for the class detailing the changes you would make. Use specific examples.

9. Pass out student worksheet: Presque Isle Bay: AOC

VOCABULARY

Beneficial uses
Biodegradation
Combined sewage outfalls
Drainage basin divide
Eutrophication
Flushing
Nonpoint source pollution
Point source pollution
Polycyclic aromatic hydrocarbons (PAHs)
Urban runoff
Watershed

QUESTIONS/ INQUIRY

- ✓ What effects does development of land near streams or creeks have on the surrounding watershed? If the surrounding land does have to be developed, what are some things that can be done to protect the stream or creek from pollution due to the development?

- ✓ Brainstorm ways that pollution affects the animals in the streams and bay. List them.

ASSESSMENT

- ✓ Students should have gained an understanding of what a watershed is, and they should be able to identify where their watershed is located. They should also have gained an understanding of how polluting streams can affect their community.
- ✓ Students will present their ideal watershed to the class. Assess for organizational skills, content, and accuracy.
- ✓ Students will be assessed for completion and correctness of their worksheet.

GLOSSARY

Beneficial use: Impaired beneficial use means a change in the chemical, physical, or biological integrity of the Great Lakes system sufficient to cause detrimental changes to the ecosystem.

Biodegradation: The natural process of plant decay and decomposition.

Combined sewage outfalls: Under "non- rain event" situations (normal flow conditions) the wastewater flows to the wastewater treatment plant to be processed. During large rain events, the excess flow causes the rainwater and wastewater to be mixed and a portion of the wastewater flows directly into the bay.

Drainage basin divide: A ridge that separates one drainage basin from another. One example is the ridge that separates the Lake Erie Basin drainage from the Allegheny Basin drainage.

Eutrophication: The natural aging process of a lake whereby the lake goes from low production to high production as a result of enrichment by nutrients.

Flushing: The natural process of water replacement in an estuary; for example, Presque Isle Bay is flushed every 2.5 years by lake water and other runoff. In other words, it takes 2.5 years for water entering Presque Isle Bay from a storm to get to Lake Erie.

Nonpoint source pollution: Pollution that results from runoff of melting snow or rainwater picking up pollutants as it is carried to streams and lakes. These pollutants consist primarily of sediments and nutrients, but can carry bacteria, viruses, oils, grease, toxic chemicals, and heavy metals. The number one source of nonpoint source pollution is crops and livestock.

Point source pollution: Pollution that originates from a specific identifiable source such as a pipe from a factory. Other sources could be discharge from wastewater treatment plants, or other industrial sources.

Polycyclic Aromatic Hydrocarbons (PAHs): A family of organic compounds derived from fossil fuels and their combustion. The higher molecular weight PAHs are an environmental concern because they can cause cancer in humans and animals.

Watershed: The land area drained by a river or stream. The watershed is the natural hydrologic unit associated with numerous ecological and physical processes involving water. Increasingly, the watershed is being accepted as the most appropriate geographic unit for management of water quality.

REFERENCES

- ✓ Presque Isle Ecosystem Study: Background Report. Potomac-Hudson Engineering, Inc.; Bethesda, Maryland; June 1991.
- ✓ Environmental Protection Agency: Presque Isle Bay 43rd Area of Concern http://www.epa.gov/glnpo/aoc/presque
- ✓ Nyer, Randy EES Presque Isle State Park; DCNR/PA Bureau of State Parks/Environmental Education and Information Division; Watershed Curriculum, 2000.

INVASIVE SPECIES:

ZEBRA MUSSELS & ROUND GOBIES

GRADE LEVEL / SUBJECT
Grade 7: Ecology/ Environmental Science

TIME One class period

PURPOSE The purpose of this lesson is to introduce students to invasive species and help them to understand the difference between exotic and invasive species as well as the impacts these species can have on ecosystems of the Great Lakes and Presque Isle Bay.

OVERVIEW Exotic species are organisms that are introduced into habitats where they are not native. Sometimes these species can become invasive, and have detrimental effects on the ecology of the environment by driving out native species and altering the biodiversity. Without natural predators, they can often displace native species and impact recreation, water quality, pollutant cycling, and habitat. In Presque Isle Bay and Lake Erie, two aquatic invasive species that are having significant impacts on these ecosystems are the zebra mussel and the round goby.

OBJECTIVES
At the end of this lesson students will be able to:

- ✓ Identify the difference between and exotic and an invasive species.
- ✓ Identify a zebra mussel and a round goby.
- ✓ List the environmental impacts invasive species have on ecosystems.
- ✓ Identify courses of action that can be taken to prevent the spread of exotics to other waterways.

RESOURCES / MATERIALS
Aquatic Exotics handout for each student
Figure 1 and 3 copied for each student
Computer with Internet access-optional
Worksheet for each student

PRIOR KNOWLEDGE
Food web

MOTIVATION
Imagine that aliens from Mars invaded our earth, how would they affect human life as we know it? What would they eat? Where would they live? What if they lived next door to you? Now think of the same situation except in an aquatic habitat like a

pond or lake. The aliens can be compared to an invasive species. **Invasive species** are non native organisms that invade habitats and disrupt the natural ecological cycles of the habitat. The invasion of an aquatic invasive species is like having a new neighbor coming to live in your neighborhood, except the new neighbor forces you to move ten miles across town so they can have more space. They go to the local market and buy all of the food on the shelves so there is nothing left for anybody else. You are forced to move across town because there is no more food at the store. Eventually other families are forced to move as well, and in the end the only ones left in the neighborhood are the new resident aliens. This is what can happen in an aquatic ecosystem if a non- native species is introduced.

BACKGROUND INFORMATION

What is an exotic species?

Exotic species are non-native organisms that invade habitats. Sometimes these intrusions are harmless, even beneficial. Other times however, these invaders can disrupt the **biodiversity** and natural ecology of the habitat. When an exotic species causes harm to the economic, health, or ecological well being of a habitat, it is called an **invasive species**.

Invasive species can often over run their new home and crowd out, or out compete, **native species.** Invasive species can grow and expand in huge numbers very quickly due to an abundant food supply in the new environment and a lack of natural predators. So how do exotics get to where they don't belong? Most introductions are done by humans, some intentionally, other unintentionally. Species can be easily transported from one area to another by:

So how do these exotics get to where they don't belong? Most of the introductions of exotic species are done by humans. They can be introduced into a habitat intentionally or unintentionally. Those introductions that are intentional sometimes do unexpected damage. However, many of the exotic introductions are accidental. The species can be transported to other areas on animals, vehicles, ships, commercial goods, produce, and even clothing. Some exotic introductions are ecologically harmless and some are even beneficial: however most exotic introductions become invasive species and have a negative effect on our ecosystems. Invasives have been responsible for the extinction of native species, especially those of confined habitats such as islands and landlocked aquatic ecosystems. Aquatic nuisance species of concern in the Great Lakes region are the zebra mussel, quagga mussel, round goby, Eurasian ruffe, sea lamprey and spiny waterflea. Two of these commonly found in Lake Erie and Presque Isle Bay are the zebra mussel and round goby.

Zebra Mussels

Zebra Mussels are small fingernail sized freshwater **mollusks** (Figure 1) that live at the bottom of lakes and streams and in both freshwater and estuarine water habitats. Zebra mussels start to reproduce in Lake Erie once the water temperature reaches 13 ° degrees centigrade. One female mussel can produce up to 1 million eggs per year. Wow! The eggs are fertilized externally when both eggs and sperm are released into the water. The fertilized eggs develop into free-floating larvae called **veligers**. These larvae remain in this planktonic stage for 10 to 15 days and are carried by water currents which enables them to expand their distribution. After the 10 to 15 days of floating around and being carried by the current, the veligers begin to act more mussellike and move around searching for some place to attach. They attach themselves to surfaces using very tough elastic fibers called **byssal threads** (Figure 2). This is called the settling phase during which the mussels start to form their shells.

Once the mussels begin to grow, they like to attach to hard substrates and tend to colonize in large clumps by growing on top of one another (see below example of

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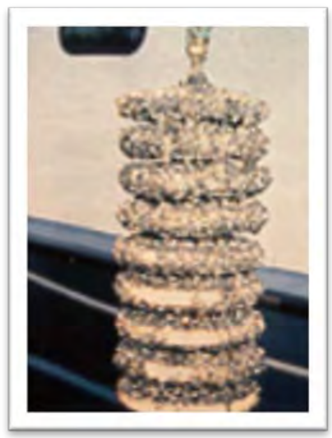

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how fast zebra mussels can colonize an object).

Zebra mussels like other aquatic organisms need good water quality and an abundant food source (**plankton**) to be successful in colonizing a lake or river. They need certain physical and chemical conditions of the water (pH, temperature, salinity, water velocity) in order to survive. In addition they need appropriate biological conditions (food sources, lack of predators) to be successful. In the case of zebra mussels, a lack of natural predators has helped them expand their populations.

Zebra mussels are **filter feeders** and get their food by filtering tiny organisms out of the water. When they feed they remove microscopic aquatic plants (phytoplankton or **algae**) and animals (**zooplankton**) from the water. They have the ability to filter about one liter of water per day. It is believed that the zebra mussel colonies in Lake Erie filter the entire volume of the lake's western basin each week! This filtering increases the clarity of the water and reduces some forms of **phytoplankton** (by as much as 80 percent). Plankton forms the basis of the lake food web. With increased clarity of the water, sunlight is able to penetrate deeper into the water, which increases the growth of aquatic plants and bottom dwelling algae as well as some aquatic insects. It also changes the habitat for fish. Some lakes have seen a change in fish species because the increase of aquatic plants changes the habitat preference of the fish living there.

Where did they come from?

Zebra mussels originally inhabited the Caspian Sea (Map 1) and were brought to the Great lakes region in the **ballast water** of transoceanic ships. This ballast water, taken on in a freshwater European port was then discharged into Lake St. Clair, near Detroit, where the mussel was discovered in 1988. Since that time, they have spread rapidly throughout the Great Lakes and the Mississippi River System, as well as Ontario and Quebec (Figure 1).

Impact

The effect that zebra mussels have on the area they invade can be devastating. The mussels attach themselves to the shells of other freshwater clams (at right) using their byssal threads. These threads are very strong and prevent the zebra mussel from being washed away with the current. If enough zebra mussels build up on the clam's shell, the clam is unable to open and close to feed and it will die. This has resulted in zebra mussels eliminating most **native species** of clams in Lake Erie.

The native clams are not the only organisms affected by the zebra mussel. They have also been found to affect crayfish (at left), snails and turtles. Since zebra mussels can filter huge volumes of water, and have a high body-fat content they can accumulate about 10 times more contaminants than native mussels. These contaminants can be transferred up the food chain to waterfowl and fish that eat zebra mussels. This can pose a threat to humans if the fish have higher levels of contaminants because of the zebra mussels in the food chain. Zebra mussels have also made impacts on commerce and industry by clogging water intake pipes and disrupting the flow of drinking water supplies in many areas.

Treatments

The most effective treatment used in preventing the zebra mussels from colonizing intake pipes is chlorination. This treatment is approved by the Environmental Protection Agency as a means of controlling the clogging of intake pipes. Poisons have been developed that kill zebra mussels but at this point researchers and scientists are still searching for a way to safely treat the zebra mussels without causing harm to other organisms in the ecosystem. We have tried to remedy the impacts of zebra mussels but most scientists believe that zebra mussels cannot be eliminated, so the goal now is to learn how to live with them.

Relationship to Presque Isle

The zebra mussels that inhabit Presque Isle Bay and Lake Erie have made some significant impacts on the ecosystem of the bay and lake. Because of the zebra mussels ability to filter plankton out of the water, they have caused an increase in the clarity of the water. As discussed before, an increase in water clarity can lead to an increase in the growth of aquatic vegetation, and can also raise water temperature. The increase in vegetation can cause problems for boaters in the bay by clogging propellers and also affects fish habitat. Fisheries biologists have noticed changes in fish species because the increase in vegetation favors certain fish species. For example in Lake St. Clair there has been a change in fish species from walleye and yellow perch to largemouth bass and northern pike.

Round Gobies

The round goby (Figure 3) is a bottom dwelling fish that perches on rocks and other substrates. Gobies have large heads, soft bodies and their dorsal fins that lack spines. They can grow up to 10 inches long as adults. They are very aggressive fish, feeding on the eggs of native fish and aggressively defending spawning sites, thereby impacting reproduction of native fish species. The round goby is a multiple spawner (may nest several times a year) and produces from 300-5,000 large eggs per year! The eggs are deposited in nests on the tops or undersides of rocks, logs or cans and the male goby guards the nest. The habitat of the round goby is primarily the rocky, gravel areas nearshore, which can help protect the developing young. The gobies pelvic fin acts like a suction cup allowing the fish to hold on to substrates in times of high water flow.

In Europe, the diet of round goby consists primarily of clams and mussels and large invertebrates. Here in the United States, studies have revealed that the diet of the round goby includes insect larvae, but more interestingly, the zebra mussel. Some natural predators of the round goby include sport fish like smallmouth bass, rock bass, walleye, and yellow perch. Round gobies often are mistaken for the sculpin, a native bottom- dwelling fish. The distinguishing feature between the sculpin and goby is the fused pelvic fin (Figure 4). Sculpins and round gobies are similar in coloration however, round gobies also have a black spot on the dorsal fin.

Where did they come from?

The round goby originally came from the Black and Caspian Seas (Map 1). It was first discovered in the United States in the St. Clair River in 1990. Like the zebra mussel, they were most likely transported to the U.S. in the ballast water discharged by transoceanic vessels. Because the round goby spawns several times a year, produces numerous eggs and aggressively protects its habitat, it was able to successfully reproduce and colonize quickly once it was introduced.

Impact

The round goby competes successfully with native fish such as the sculpin. A decrease in native sculpin populations has been reported from areas in which gobies have become established. The goby competes with the sculpin for food and also drives them from their preferred spawning areas. Gobies affect other types of native fish by consuming their eggs and young, which reduces the population of those native fishes. On the positive side, the gobies' diet consists largely of another exotic species: the zebra mussel. The zebra mussel is an important component of the gobies' diet and a single goby can consume up to 78 zebra mussels a day! Although this number might seem large, it is unlikely that the goby would have a noticeable impact on the zebra mussel population; however, due to the abundance of zebra mussels for food, the goby population is increasing exponentially.

Relationship to Presque Isle Bay

Although, the zebra mussel has done much to clear up the water in Presque Isle Bay, the ingestion of contaminants by the zebra mussel while filtering the water has created problems for anglers. Since the round goby primarily feeds on zebra mussels, the contaminants the zebra mussel uptakes while filtering the water builds up in their tissues and gets transferred to the round goby. The fish that consume the round goby such as smallmouth bass, walleye and perch also ingest the contaminants that the round goby got from the zebra mussel. This is where humans are potentially impacted. We fish for many of the same fishes that are eating the round goby. When we consume some of these fish, we could also be consuming some of the contaminants contained in the fish tissues. Fish advisories are currently issued for Presque Isle Bay and Lake Erie to inform anglers on the safe levels of consumption for certain fish. Round gobies may drive these advisories to more restrictive levels.

Control and prevention of invasive species

Refer to Figure 1 and Figure 3 for "How to stop the spread"

Everybody can make a difference and help stop the spread of invasive species. In 1990 the Nonindigenous Aquatic Nuisance Prevention Act was passed to prevent the new introduction of species into the Great Lakes via ballast water and to create a national program to prevent the entry of invasive species. This act was expanded with the Native Invasive Species Act (NISA) of 1996. Action on the local level is essential to prevent the spread of invasives. Invasive species such as zebra mussels can be picked up and transported on equipment, including boats, trailers, motors, tackle, anchors, axels and centerboards. Others species like round gobies, waterfleas and zebra mussel veligers can be carried in the water of livewells, baitbuckets, motors, bilges, and transom wells. People should be aware that even a small cluster of zebra mussels in a baitbucket could lead to an infestation of an entire waterway. Invasive species that are used as bait such as the round goby can also be transported by anglers and bait dealers into other waterways. Properly cleaning boats and disposing of bait can help reduce the spread of the round goby and zebra mussel.

PROCEDURE

1. Begin class by asking students if they have ever heard of the term exotic species before. Motivate them by reading the story about the earth being invaded by aliens from Mars. Following the story, ask the students again if they have an idea what an exotic species is. Ask for their thoughts.
   Hint: Define each word (exotic, species) with the students, and then put them together and see what you get.
2. Ask the students if they have ever heard the term invasive species before. Help explain to them the differences between the term exotic and invasive. Exotic species may not always be harmful and can sometimes be beneficial. Invasive species does ecological and environmental harm.
3. Handout enclosed Aquatic Exotic Species of the Great Lakes Region sheet. Discuss the different organisms pictured. Why would these be considered exotic? Do they look different than other organisms? Ask for students' thoughts.
4. Discuss what an invasive species is. Refer to Aquatic Exotic Species of the Great Lakes Region sheet. Ask students to look at each organism pictured and think of how they might have been introduced into a new habitat and why?

   Hint: The round goby and ruffe are both fish. Can they swim from one habitat to another?
5. Call attention to the zebra mussel pictured in the handout.
6. Handout Figure 1 and display Figure 2. Begin to discuss the basic characteristics of the zebra mussel life cycle. Review the "how to identify it" section of the handout and discuss other noticeable characteristics that could be used for identifying the zebra mussel. Make a list of any additional characteristics that could be used to identify zebra mussels.
7. Discuss the colonizing capabilities of the zebra mussel and relate it to their reproduction.
8. Review "Where did they come from?" Refer to Map 1 (Caspian Sea) to familiarize the students with where the Caspian Sea is located.

9. Discuss what types of impacts or changes the zebra mussel has made on the ecosystem. Ask how the mussels might affect other organisms.

10. Refer to Aquatic Exotic Species of the Great Lakes Region and bring their attention to the Round Goby.

11. Handout Figure 3. Begin to discuss the basic characteristics of the round goby. Review the "how to identify it" section of the handout and discuss other noticeable characteristics that could be used for identifying the round goby. Make a list of any additional characteristics that could be used to identify round gobies.

12. Display Figure 4. Point out the differences in pelvic fins between the sculpin and the round goby.

13. Refer to Map 1 and review "Where did they come from?" Point out the Caspian and Black Seas as the native homes of the round goby. Refer to the distribution map on Figure 3 and discuss how the goby might have arrived in the United States.

    Hint: Think about the differences between the zebra mussel and round goby in terms of their mobility. Which one would have an easier time moving around?

14. Discuss the types of impacts or changes the round goby has made on the ecosystem, both positive and negative. Critically think about how the round goby's diet could potentially affect humans.

15. Wrap up: Talk with students about how they can become actively involved to prevent the spread of exotic species. Perhaps they or someone in their family likes to fish.They can help by telling them what they learned about the zebra mussel and round goby and how they impact the ecosystem.

16. Pass out student worksheet: Exotic Species.

VOCABULARY

Background:

Exotic species

Invasive species

Biodiversity

Native species

Ballast water

Zebra Mussels:

Algae

Bivalves:
Byssal threads
Exotic species
Filter feeder
Larva
Mollusks
Phytoplankton
Plankton
Veliger
Zooplankton

QUESTIONS/INQUIRY

CLASS DISCUSSION:

Why should we be concerned about invasive species? What impacts do they have on ecosystems? How can the transfer of invasive species be controlled or stopped in the Great Lakes?

CREATIVE WRITING:

Provide a list of terms that the students can make into a story about a zebra mussel or a round goby making the trip from their original "homeland" to their new habitat.

EXTENSION:

Research on the Internet other geographical areas that have been impacted by zebra mussels or round gobies. What impacts have they had in those communities? What have they done to control them?

ASSESSMENT

- ✓ Students will be assessed on their ability to correctly identify both a zebra mussel and round goby using the distinguishing characteristics provided in the fact sheets.
- ✓ Students will be assessed on the completion and correctness of their worksheet.

GLOSSARY

Algae: A photosynthetic plant-like protist (single celled eukaryotes).

Ballast water: Water stored in tanks on large ships to help maintain the ships buoyancy and balance.

Biodiversity: Measure of the number of different species and individuals living in an ecosystem.

Bivalve: A mollusk having shells divided into halves.

Byssal threads: Tough elastic threads formed from secretions of the byssal gland in the zebra mussel. Zebra mussels use them to attach themselves to rocks, docks, boats and the shells of other animals.

Exotic species: Organisms that are introduced into habitats in which they are normally not found.

Filter feeder: Organisms that filter the water using specialized organs such as gills to trap fine food particles for feeding.

Invasive species: Organisms introduced into habitats where they are normally not found and cause ecological harm.

Larvae: A free-living, sexually immature form in some animal life cycles that may differ from the adult in morphology, nutrition, and habitat.

Mollusks: (Phylum Mollusca) Examples include snails, slugs, oysters, clams, octopuses and squids. Mollusks are soft-bodied animals, but most are protected by a hard shell made of calcium carbonate. Zebra Mussels are bivalves that are characterized by having shells divided into to halves which protect their soft-bodied insides.

Native species: Organisms that are residents in a habitat or that which naturally occur there

Phytoplankton: The plants of the group: plankton

Plankton: The floating or weakly swimming micro-organisms found in aquatic habitats.

Veliger: Larval stage of the zebra mussel.

Zooplankton: The animals of the group: plankton.

REFERENCES

- ✓ Minnesota Sea Grant. A Field Guide to Aquatic Exotic Plants and Animals http://www.d.umn.edu/seagr/areas/exotic/x9.html
- ✓ Griffiths R., Kovalak W., Schloesser S.; The Zebra Mussel, Dreissena Polymorpha, In North America: Impact on Raw Water Users.
- ✓ Ohio Sea Grant College Program Fact Sheet; Zebra Mussels in North America: *The invasion and its implications*. 1997.

Aquatic Invasive Species of concern in the Great Lakes Region

Zebra mussel

Round goby

Eurasian ruffe

Sea lamprey

Spiny waterflea

Map 1: Caspian Sea

How to Identify It:

- ⇒ *Look for a yellowish or brownish "D" shaped shell with dark and light colored stripes*
- ⇒ *Average size is 1 inch, but can be as large as 2 inches*
- ⇒ *Grow in clusters in shallow (6-30ft) algae-rich water*

How to Stop the Spread:

- ⇒ *Inspect boat, trailer and equipment and remove any zebra mussels*
- ⇒ *Empty bait bucket on land. Do not release live bait into a waterway*
- ⇒ *Learn what zebra mussels look like, and know which waterways are infested*

New York Sea Grant

Zebra mussel range September 1999

Figure 1: Zebra Mussel Facts

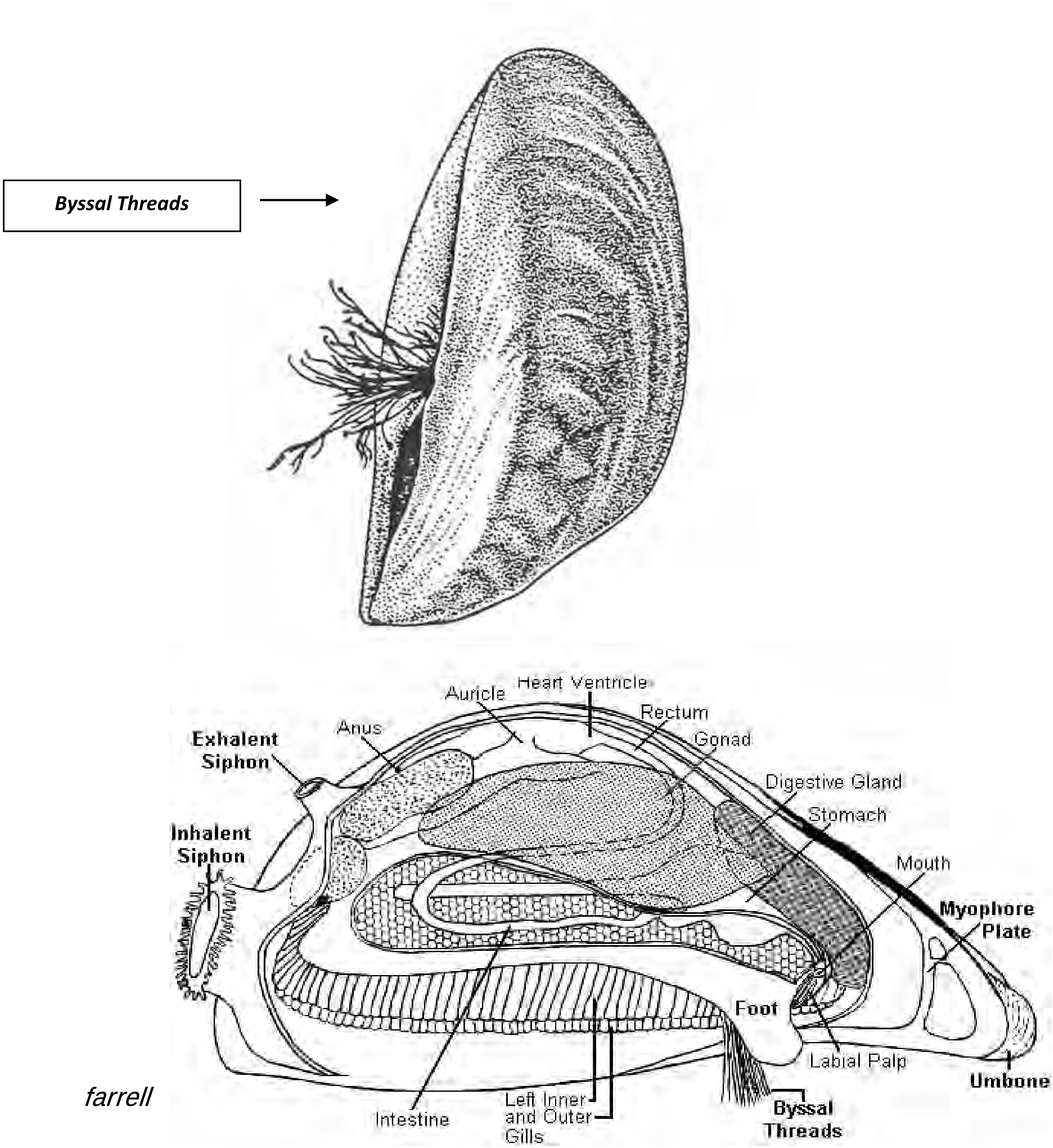


Figure 2: Adult Zebra Mussel

How to Identify It:

- ⇒ *Dark blotch on dorsal fin*
- ⇒ *Fused pelvic fins*
- ⇒ *Frog-like raised eyes*
- ⇒ *Thick lips*
- ⇒ *Body mostly slate gray in color mottled with black to brown spots*

How to Stop the Spread:

- ⇒ *Learn to identify the round goby*
- ⇒ *Always drain water from boat before leaving any waterway*
- ⇒ *Never dump live fish from one body of water into another*
- ⇒ *Always dispose of unwanted bait on land*

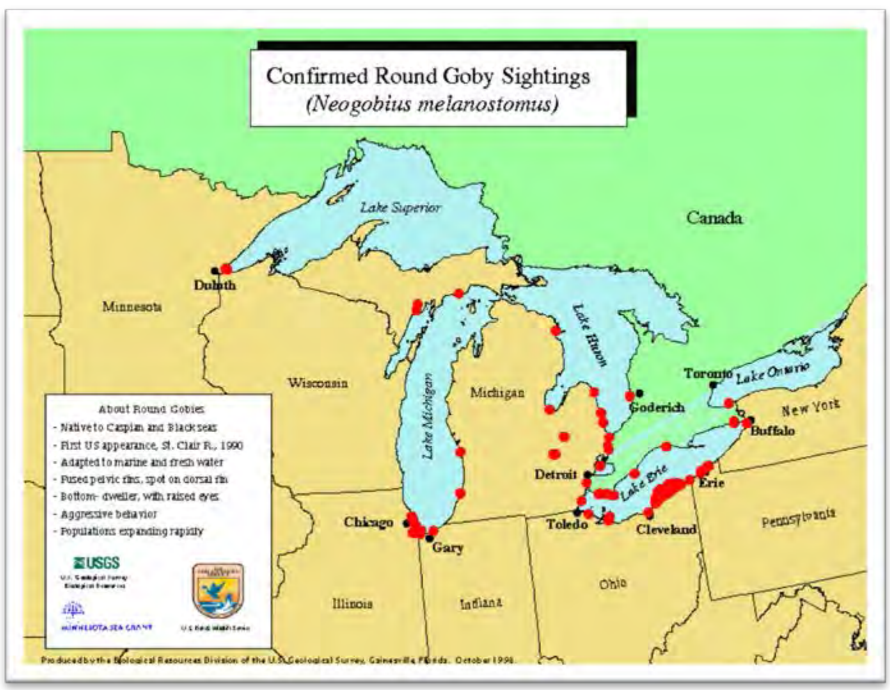
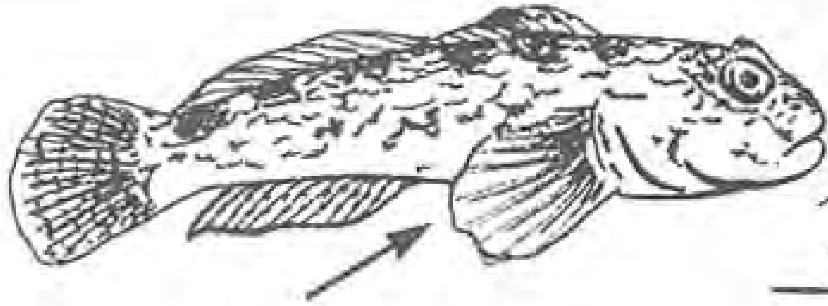
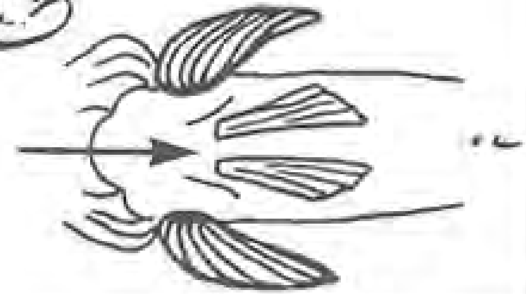
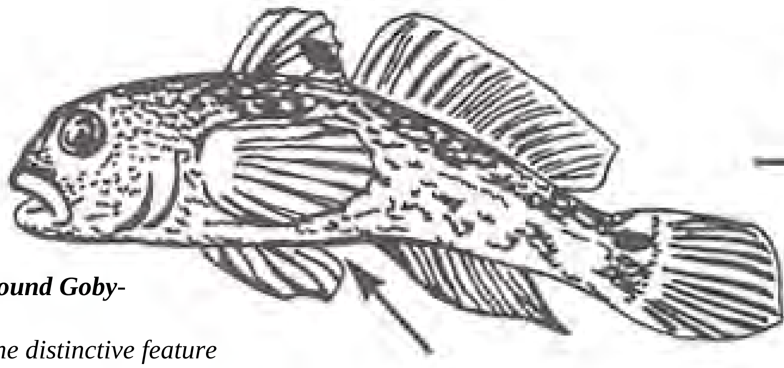
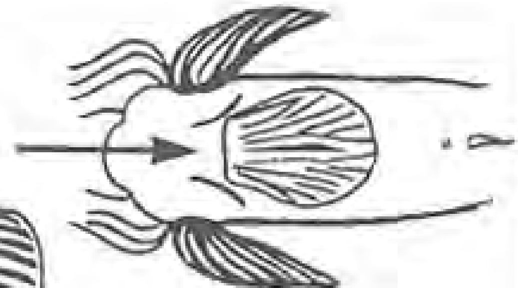


Figure 3: Round Goby Facts

Sculpin- *Sculpins have separate pelvic (bottom) fins. A dark spot on the dorsal fin is common.*

Round Goby-

The distinctive feature

of the round goby is its fused pelvic (bottom) fins.

This fish can grow up to 10 inches in length, although 3 to 6 inch fish are more common.

Figure 4: Round Goby and Sculpin

RESOURCES

Invasive Species

Name:_____________________ Date: _________Class:____________

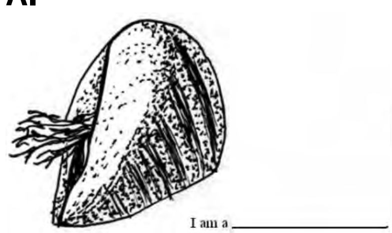
Section I: Completion

Non-native	*Ballast*	*Round gobies*	*Zooplankton*
Native	*Sculpins*	*Filter feeders*	*Biodiversity*
Invasive	*Byssal threads*		

1. Exotic species are species that are _____________ to their environment, while ___________ species are both non-native and cause ecological harm.
2. Zebra mussels and round gobies came to the United States from the Caspian Sea through the _________________ water of oceanic ships.
3. Zebra mussels are _________________ and can filter up to 1 liter of water per day!
4. Using their ____________ , zebra mussels are able to firmly attach themselves to solid surfaces as well as other organisms like crayfish.
5. _________ have a fused pelvic fin, ___________ do not.

Section II. Label Me!

A.



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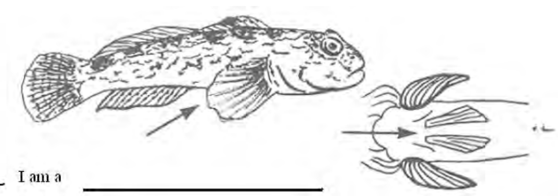

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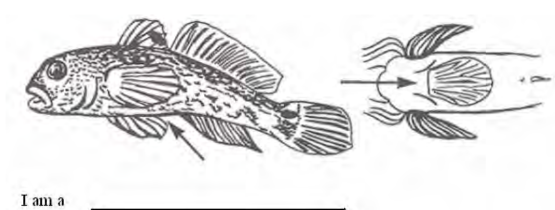

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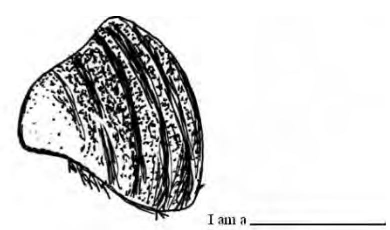


Word Bank:

Sculpin *Zooplankton* *Quagga Mussel* *Zebra Mussel* *Round Goby* *Biodiversity*

Section III: Critical Thinking

Remembering what you learned about invasive species, what do you think you could do to prevent other exotic species from entering your watershed?

Key to Macro-life

1a. *I have a shell...2*

1b. *I do not have a shell...3*

2a *(1a). I have a single shell 4*

2b. *I have a double shell 5*

3a *(1b). I have legs...6*

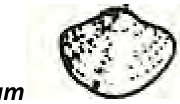
3b. *I do not have legs...7*

4a *(2a). I have a spiral opening on the left ....**Pouch snail***

4b*. I have a spiral opening on the right .... **Gill snail***

4c. *I have a coiled shell………………………………………………………….**Orb snail***

4d. *I have a conical shell…………………………………………………………..**Limpet*** 

5a *(2b). I am tiny and white ....**Fingernail clam*** 

5b. *I am large, generally 2 to 8 inches.................... **Freshwater mussel***

5c. *I am small with stripes and a ridge on my side that lets me sit flat……..**Zebra mussel***

5d. *I am tiny with stripes and rounded; I cannot sit flat on my side……….**Quagga mussel***

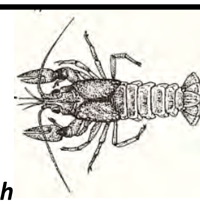
6a *(3a). I have more than 10 pairs of legs…………………………………………………8*

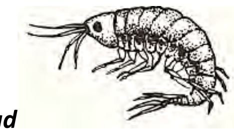
6b. *I have Four pairs of legs………..……………………………………………………9*

6c. *I have 3 pairs of legs…………………………………………………………………10*

7a *(3b). I have tentacles, brushes, or tails………………………………………………..11*

7b. *I am worm-like…………………..……………………………………………………12*

8a *(6a). I am lobster like……………………………………………………………* ***Crayfish*** 

8b*. I am shrimp-like and swim on my side……………………………………………* ***Scud*** 

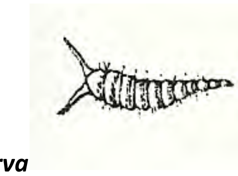
8c*. I have a segmented body, 2 pairs of antennae; 7 pairs of legs………* ***Aquatic sowbug*** 

9a *(6b). I am tiny, spider-like; and swim quickly in the water……………….* ***Water mite*** 

9b*. I run on top of the water…………………………………………………..* ***Fishing spider*** 

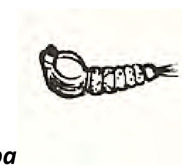
10a *(6c). I have wings……………………………………………………………………13*

10b. *I do not have wings……………………………………………………………………14*



__11a__ (7a). I have two feathery fringed tails on my back end……….__Water Snipe Fly larva__

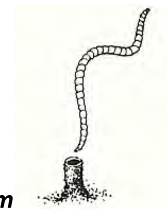
__11b__. I am large and white or grey with tentacles………………………..……..__Cranefly larva__



__11c__. I am have a large head and am very active………………………………__Midge pupa__

__11d__. I am small, black, have gills near my head and attach to rocks……….__Blackfly larva__

12 a (7b) I have suckers, I expand and contract .... **Leech** 



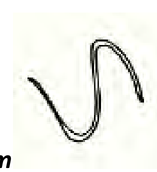
12b. I am reddish brown and bury my head in the bottom mud ....***Tubifex worm***

12c. I am flat, glide along the bottom, and have two light sensitive "eyes" on my head

.. Planaria/Flatwormagre

12d. I am tan to brown and very long .... ***Horsehair worm***

12e. I am red or greenish and segmented…………………………………..….***Midge larva***



12f. I am thin and cylindrical, 1-30 mm long……..……………….……..***Aquatic worm***

13a *(10a) I am beetle like, with hard wings…………………………………….…….15*

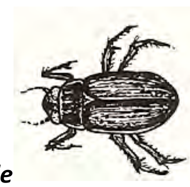
__13b__ I have leathery wings……………………………………………………….………16

__14a__ (10b). I have no obvious tails…………………………………………………..….17

__14b__. I have one or two tails………………………………………………………….…..18

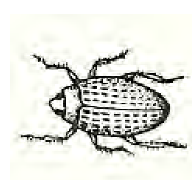
__14c.__ I have three tails……………………………………………………………………19

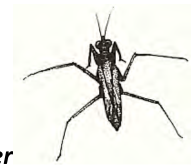
__15a__ (13a). I am small and crawl on the bottom; I have one pair of antennae...__Riffle beetle__ 

__15b.__ I swim moving hind legs alternating…………………..……__Water scavenger beetle__ 

__15c__. I move both my back legs at the same time………………__Predaceous diving beetle__ 

__15d__. I swim on the surface of the water………………………..………__Whirligig beetle__ 

__15e__. I crawl through the water, I have spots…………………..…__Crawling water beetle__ 

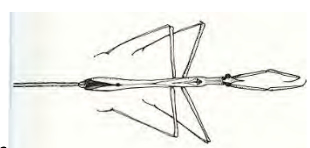


16a *(13b). I live on the surface and appear to "walk" on water…………..* ***Water strider***

16b*. I have grasping front legs, and can be up to 3 inches!!...............* ***Giant water bug***

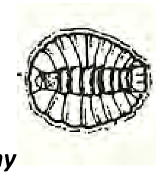
16c*. I swim upside down on my white back………………………..……….* ***Backswimmer***

16d*. I swim right side up and my back is black…………………..………* ***Water boatman***



16e*. I am long and "stick-like"……………………..………………….* ***Water scorpion***

17a**. (14a). I am green, tan, or orange in color……………………………**Caddisfly larva 

17b**. I am small, round and resemble a penny……………………………….**Water penny 

17c**. I have a robust body with two large eyes on each side of my head…………………………………………………………………..**Dragonfly nymph 

17d**. I live in a stone house……………………………………….………**Caddisfly larva 

17e**. I live in a stick house…………………………………………..…**Caddisfly larva 

18a** (14b) I have a dark head, green or tan body………………………….**Caddisfly larva 

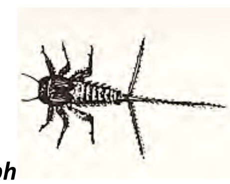
18b**. I am brown with spines/hairs on my abdomen……………………..…**Alderfly larva 

18c**. I have large mouthparts, with spines/hairs on my abdomen………..**Dobsonfly larva 

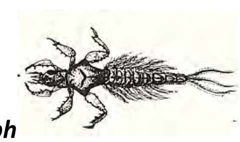
18d**. I have two distinct long tails…………………………………………..…**Stonefly larva

18e**. I have flat gills on my abdomen……………………………..……..…..**Mayfly nymph

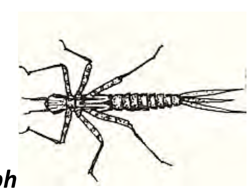
19a** (14c) I have three long tail, gills on abdomen……………………..….**Mayfly nymph



19b**. I have large legs, feathery gills……………………………..………..…**Mayfly nymph



19c**. I have three plate-like tails, no gills on abdomen………………..….**Damselfly nymph

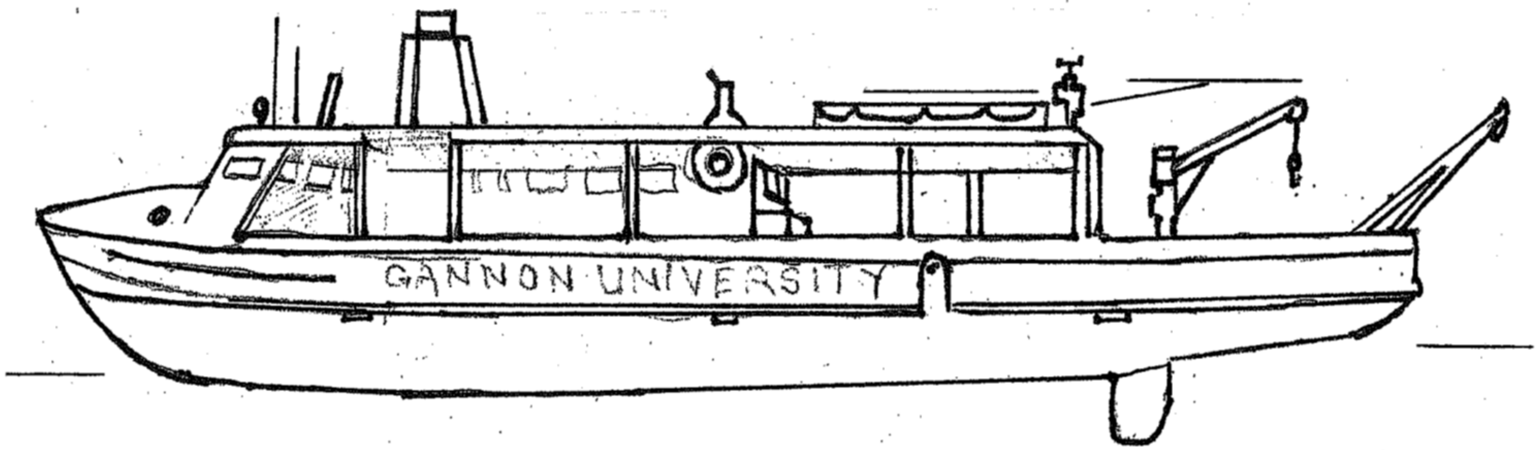


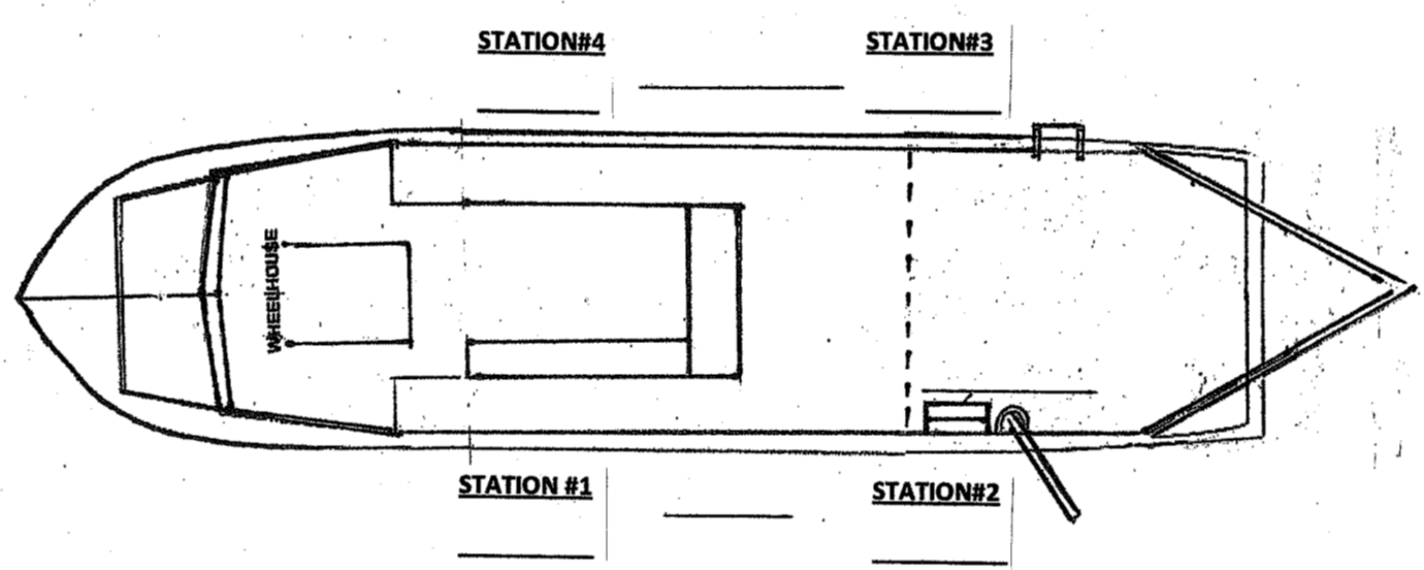
GREAT LAKES QUIZ

Name: ______________________________ Class: _________________ Date: _______

		TRUE	FALSE
1.	There are five Great Lakes.	_____	_____
2.	Lake Erie is the shallowest Great Lake at 210 feet.	_____	_____
3.	Lake Superior is the deepest Great Lake at 1,333 feet.	_____	_____
4.	Lake Huron is the fifth largest freshwater lake in the world.	_____	_____
5.	More fish are caught in Lake Erie each year than from all other Great Lakes combined.	_____	_____
6.	All the water combined in the Great Lakes would cover the Continental United States in 9.5 feet of water.	_____	_____
7.	The Great Lakes contain 21% of the world’s surface fresh water.	_____	_____
8.	The Great Lakes are home to over 125 species of fish.	_____	_____
9.	The Great Lakes generates $4 billion in sports fishing annually.	_____	_____
10.	42 million people live in the Great Lakes watershed.	_____	_____
11.	It takes 173 years for water to travel from Lake Superior to the ocean.	_____	_____
12.	70% of the earth is covered by water.	_____	_____
13.	Only 3% of the worlds water is freshwater. 68% of that is frozen.	_____	_____
14.	An average person can live 3 only three days without water.	_____	_____
15.	A humans body is 65% water.	_____	_____
16.	Water is a renewable resource.	_____	_____

R/V ENVIRONAUT WORKSHEET





LAKE ERIE SCIENCE
HYDROLAB DATA SHEET

SCHOOL NAME:________________________________ TEACHER NAME:______________

DATE:____________ SITE NUMBER:____________________

LATITUDE: ___________^{0}N ______' ________" LONGITUDE _______^{0}W _____' ________"

WEATHER CONDITIONS:

AIR TEMPERATURE: _________________________

WIND DIRECTION: _________________________

WIND SPEED: _________________________

CLOUD COVER: SUNNY _______

PARTLY CLOUDY _______

MOSTLY CLOUDY _______

CLOUDY _______

Depth (meters)	Temperature (^oF)	Conductivity (mhos)	Dissolved Oxygen (ppm)	pH
1				
2				
3				
4				
5				
6				
7				

LAKE ERIE SCIENCE
INVERTEBRATE DATA SHEET

SCHOOL NAME:______________________________ TEACHER NAME:_____________

DATE:____________ SITE NUMBER:____________________

LATITUDE: __________ ^{0}N ______' ________" LONGITUDE _______ ^{0}W _____' ________"

Mud Characteristics

Color	
Brown	
Black	
Grey	
Other	

Texture	
Thick	
Soupy	
Sandyrocky	
Other	

Comments

Benthic Macroinvertebrates

Organism	Number	Water Quality
Midge		
Zebra mussel		
Quagga mussel		
Scud		
Caddisfly		
Leech		
Sow bug		
Aquatic worm		
Native mussel		
Mayfly nymph		
Planarian		
Other:		
Other:		

Comments

REFERENCES

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Zebra Mussel Growth Progressions: Eric Obert
Zebra Mussels on Native Clam: Wisconsin Sea Grant
Mussels on Crayfish: Ontario Ministry of Natural Resources
Aquatic Exotics:
- Zebra Mussels-Ohio Sea Grant
- Round Goby-Shedd Aquarium
- Eurasian Ruffe-Minnesota Sea Grant
- Sea Lamprey-U.S. Fish & Wildlife Service
- Spiny Waterflea- U.S. Fish & Wildlife Service

Round Goby: D. Jude
Sieve Box: Jim Stewart

U.S. BRIG NIAGARA
ERIE MARITIME MUSEUM

Sea Grant
Pennsylvania

REGIONAL SCIENCE CONSORTIUM
at The Tom Ridge Environmental Center at Presque Isle

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